THE
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INDIA

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1937

CONTENTS

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ANNUAL MEETING

The Annual Meeting of the National Academy of Sciences, India, was held in the Vizianagram Hall, Muir College Buildings, Allahabad, at 3 P. M., on Saturday, March 5, 1938. Pandit Jawaharlal Nehru presided over the function. Dr. P. L. Srivastava, M.A., D. Phil. (Oxon), one of the General Secretaries, read the Annual Report of the National Academy of Sciences, India.

Prof. B. Sahni, Sc.D., F.R.S., the President of the Academy, gave his address. Pandit Jawaharlal Nehru, then, delivered his address.

Prof. M. N. Saha, D.Sc., F.R.S., proposed a vote of thanks to Pandit Jawaharlal Nehru and Dr. H. R. Mehra, Ph.D., seconded the vote.

Earlier in the day Rao Bahadur B. Vishwa Nath, F.I.C., Director, Imperial Agricultural Research Institute, delivered an address on Modern Developments in the Science of Soil and Plant Nutrition in the Physics Lecture Theatre, Muir College Buildings. In the evening a symposium was held on the problem of Power Supply in the United Provinces. It was also presided over by Pandit Jawaharlal Nehru. Many distinguished scientists took part in the discussion which was opened by Prof. M. N. Saha, D.Sc., F.R.S.

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SECRETARIES' REPORT

PRESENTED AT THE ANNUAL MEETING OF THE NATIONAL ACADEMY OF SCIENCES, INDIA, ON MARCH 5, 1938

BY P. L. SRIVASTAVA, M.A., D. PHIL. (OXON)

We have the honour to submit the following report on the working of the Academy during the period beginning from 1st January, 1937 to 31st December, 1937.

The Sixth Annual Meeting of the Academy was held on Friday, the 15th January, 1937 at 3 p. m. in the Vizianagram Hall, Muir College Buildings, Allahabad. Lt.-Col. R. S. Weir, M.A., B.Sc., I.E.S., Director of Public Instruction, United Provinces of Agra and Oudh, presided over the function. Dr. P. L. Srivastava, a General Secretary of the Academy, presented the annual report.

Prof. N. R. Dhar, D. Sc., Dr. ès Sciences, F.N.I., I.E.S., the outgoing president of the Academy, read his address after which Lt.-Col. R. S. Weir delivered his speech. Sir John Russell, F.R.S., Director of Rothamsted Experimental Station, also gave an address on some aspects of agricultural problems of India.

We are glad to be able to say that since its foundation the Academy has been making steady progress both as regards its membership and the standard of its publication. The Academy has now on its rolls 204 members of whom 36 were elected to the membership during the year under review. Our members are drawn from every part of the country. The Academy under its constitution elects out of its members a certain number as its Fellows on account of their distinction in scientific work. The present number of our Fellows is 99 including 4 elected during the year. 52 of our members are Fellows of the National Institute of Sciences of India.

The Proceedings of the Academy have maintained its high level both in and outside the country — the papers published in the journal have been widely appreciated and abstracted in all important Science Abstracts. We are now receiving 170 foreign and Indian scientific journals in exchange. We have published three issues of the Proceedings containing 28 papers during the year under review. The remaining part will be issued very soon. During the year the number of papers communicated to the Academy was 22.

A large number of the members of our Academy took part in the Golden Jubilee Session of the Indian Science Congress. Of the distinctions conferred on the members of this Academy may be mentioned the presidentship of the National Institute of Sciences of India to which Prof. M. N. Saha has been elected and the chairmanship, held by our President, Prof. B. Sahni, of the Botanical Section of the joint session of the Indian Science Congress and the British Association for the

Advancement of Science held in Calcutta in January, 1938. Prof. J. C. Ghosh, who is a Fellow of this Academy and also a member of its Council, has been elected General President of the next Indian Science Congress. Four of our members —— Prof. Y. Bharadwaja, Dr. K. Rangadharma Rao, Prof. M. R. Siddiqi, and the Hon'ble Sir Shah Muhammad Sulaiman —— have been admitted as Fellows of the National Institute of Sciences of India.

The financial position of the Academy, we are sorry to say, has not been quite sound. We are grateful to the Government of the United Provinces of Agra and Oudh for the grant we have been receiving for the last several years. We also gratefully acknowledge the grant of Rs. 500 by the Imperial Council of Agricultural Research for the second year in succession. We are indebted to the Allahabad Municipal Board for its grant of Rs. 80 and to Sir Shah Muhammad Sulaiman for a donation of Rs. 250. We hope that the grant made by the local Municipal Board will be increased from this year.

The paucity of funds has stood in the way of our enlarging the activities of the Academy or taking up any new programme. Although there are many important foreign scientific societies eager to exchange our Proceedings with their publications, we are not in a position to send our Proceedings to all of them as the finances do not permit us to do so. For the same reason we have not yet been able to organise a properly equipped science library. The need for a building of the Academy in which we can house our library, which is rapidly increasing in size, and hold our meetings, is urgently felt. We appeal to all who consider scientific advancement as essential to the country's wellbeing to help the Academy so as to enable us to enlarge and extend its activities.

All the meetings of the Academy have been held at Allahabad during the year except one which was held at Lucknow. We are anxious to hold meetings in other places as well. It is hoped that with the increase in the number of members residing at other academic centres the meetings will, in future, be held at other places also.

The Education Minister's Gold Medal has been awarded to Dr. M. R. Siddiqi, M.A., Ph.D., Professor of Mathematics, Osmania University, Hyderabad, Deccan, his paper having been judged to be the best published in Mathematics and Astronomy in the journals of the Academy.

The Academy sent its representatives to the jubilee celebrations of the University of Allahabad and the Indian Science Congress.

We are sorry to record the death of a distinguished member of the Academy, Dr. K. P. Jayaswal, a savant and a famous orientalist.

Dr. Usha Nath Chatterji continued to be the Special Officer of the Academy throughout the year.

We wish to express our thanks to the Office-bearers of the Academy, Members of the Council and the Special Officer for their active cooperation.

ADDRESS OF THE CHAIRMAN

DELIVERED AT THE ANNUAL MEETING OF THE NATIONAL ACADEMY OF SCIENCES, INDIA, ON MARCH 5, 1938

BY PANDIT JAWAHARLAL NEHRU

FRIENDS,

You are men of learning and many of you have distinguished records in the realm of science. Yet you have honoured me, an outsider, with an invitation to participate in this annual gathering of yours and I have most willingly accepted that invitation. Science and academic halls have not known me for many a long year, and fate and circumstance have led me to the dust and din of the market-place and the field and the factory, where men live and toil and suffer. I have become involved in the great human upheavals that have shaken in recent years this land of ours. Yet in spite of the tumult and movement that have surrounded me, I do not come to you wholly as a stranger. For I too have worshipped at the shrine of science and counted myself as one of its votaries.

Who indeed can afford to ignore science today? At every turn we have to seek its aid and the whole fabric of the world today is of its making. During the ten thousand years of human civilization, science came in with one vast sweep a century and half ago, and during these 150 years it proved more revolutionary and explosive than anything that had gone before. We who live in this age of science live in an environment and under conditions which are totally different from those of the pre-scientific age. But few realise this in its completeness, and they seek to understand the problems of today by a reference to a yesterday that is dead and gone.

Science has brought all these mighty changes and not all of them have been for the good of humanity. But the most vital and hopeful of the changes that it has brought about has been the development of the scientific outlook in man. It is true that even today vast numbers of people still live mentally in the pre-scientific age, and that most of us, even when we talk glibly of science, betray it in our thoughts and actions. Even scientists, learned in their particular subjects, often forget to apply the scientific method outside that charmed sphere. And yet it is the scientific method alone that offers hope to mankind and an ending of the agony of the world. This world is racked by fierce conflicts and they are analysed and called by many names. But essentially the major conflict is between the method of science and the methods opposed to science.

In the early days of science there was much talk of a conflict between religion and science, and science was called materialistic and religion spiritual. That conflict hardly seems real today when science has spread out its wings and ventured to make the whole universe its field of action, and converted solid matter itself into

airy nothing. Yet the conflict was real for it was a conflict between the intellectual tyranny imposed by what was deemed to be religion and the free spirit of man nurtured by the scientific method. Between the two there can be no compromise. For science cannot accept the closing of the windows of the mind, by whatever pleasant name this might be called; it cannot encourage blind faith in someone else's faith. Science therefore must be prepared not only to look up to the heavens and seek to bring them under its control, but also to look down, unafraid, into the pit of hell. To seek to avoid either is not the way of science. The true scientist is the sage unattached to life and the fruits of action, ever seeking truth wheresoever this quest might lead him. To tie himself to a fixed anchorage, from which there is no moving, is to give up that search and to become static in a dynamic world.

Perhaps there is no real conflict between true religion and science but, if so, religion must put on the garb of science and approach all its problems in the spirit of science. A purely secular philosophy of life may be considered enough by most of us. Why should we trouble ourselves about matters beyond our ken when the problems of the world insistently demand solution? And yet that secular philosophy itself must have some background, some objective, other than merely material well-being. It must essentially have spiritual values and certain standards of behaviour, and, when we consider these, immediately we enter into the realm of what has been called religion.

But science has invaded this realm from many fronts. It has removed the line that was supposed to separate the world of things from the world of thought, matter from mind; it has peeped into the mind and even the unconscious self of man and sought the inner motives that move him; it has even dared to discuss the nature of ultimate reality. The reality of even a particle of matter, we are told, is not its actuality but its potentiality. Matter becomes just a "group agitation" and nature a theatre for such agitations or "for the inter-relations of activities." Everywhere there is motion, change, and the only unit of things real is the 'event', which is, and instantaneously is, no more. Nothing is except a happening. If this is the fate of solid matter, what then are the things of the spirit?

How futile the old arguments seem in view of these astonishing developments in scientific thought! It is time we brought up our minds in line with the progress of science and gave up the meaningless controversies of an age gone-by. It is true that science changes and there is nothing dogmatic or final about it. But the method of science does not change and it is to that we must adhere in our thought and activities, in research, in social life, in political and economic life, in religion. We may be specks of dust on a soap-bubble universe, but that speck of dust contained something that was the mind and spirit of man. Through the ages this has grown and made itself master of this earth and drawn power from its innermost bowels as well as from the thunderbolt in the skies. It has tried to fathom the secrets of the

universe and brought the vagaries of nature itself to its use. More wonderful than the earth and the heavens is this mind and spirit of man which ever grows mightier and seeks fresh worlds to conquer.

That is the task of the scientist, but we know that all scientists are not fashioned in the heroic mould, nor are they the philosopher-kings of whom Plato told us in the days of old. Kingliness might not be theirs but even philosophising is often lacking, and the day's task follows a narrow sphere and a dull routine. As they specialise, and specialise they must, they lose sight of the larger picture and become pedants out of touch with reality. In India the political conditions under which we have had the misfortune to live have further stunted their growth and prevented them from playing their rightful part in social progress. Fear has often gripped them, as it has gripped so many others in the past, lest by any activity or even thought of theirs they might anger the government of the day and thus endanger their security and position. It is not under these conditions that science flourishes or scientists prosper. Science requires a free environment to grow. When applied to social purposes, it requires a social objective in keeping with its method and the spirit of the age.

That fear complex which oppressed India has happily disappeared to a large extent owing to the activities and movements initiated by our great organization, the National Congress, and even the poor hungry and miserable peasant has a franker look today and a straighter back. It is time that the shadow of that fear and apprehension vanished from our academic halls also.

We have vast problems to face and to solve. They will not be solved by the politicians alone for they may not have the vision or the expert knowledge; they will not be solved by the scientists alone for they will not have the power to do so or the larger outlook which takes everything into its ken. They can and will be solved by the cooperation of the two for a well-defined and definite social objective.

That objective is necessary for without it our efforts are vain and trivial and lack coordination. We have seen in Soviet Russia how a consciously held objective backed by coordinated effort can change a backward country into an advanced industrial State with an ever-rising standard of living. Some such method we shall have to pursue if we are to make rapid progress.

The greatest of our problems is that of the land, but intimately connected with it is that of industry. And side by side with these go the social services. All of these will have to be tackled together and coordinated together. That is a vast undertaking but it will have to be shouldered.

Soon after the formation of the Congress Ministries, in August last, the Working Committee of the Congress passed a resolution which should interest scientists and experts. I should like therefore to draw your attention to it. It ran thus:

> "The Working Committee recommends to the Congress Ministries the appointment of a Committee of Experts to consider urgent and vital problems

the solution of which is necessary to any scheme of national reconstruction and social planning. Such solution will require extensive surveys and the collection of data, as well as a clearly defined social objective. Many of these problems cannot be dealt with effectively on a provincial basis and the interests of adjoining provinces are interlinked. Comprehensive river surveys are necessary for the formulation of a policy to prevent disastrous floods, to utilize the water for purposes of irrigation, to consider the problem of soil erosion, to eradicate malaria, and for the development of hydro-electric and other schemes. For this purpose the whole river valley will have to be surveyed and investigated, and large-scale State planning resorted to. The development and control of industries require also joint and coordinated action on the part of several provinces. The Working Committee advises therefore that, to begin with, an inter-provincial committee of experts be appointed to consider the general nature of the problems to be faced, and to suggest how, and in what order, these should be tackled. The Expert Committee may suggest the formation of special committees or boards to consider each such problem separately and to advise the provincial governments concerned as to the joint action to be undertaken."

The rest of the resolution dealt with the sugar industry.

Something has been done in this respect, a Power Alcohol and other committees have been appointed, but I wish more had been done. I should like an aggressive and widespread tackling of our problems by experts. I should like museums and permanent exhibitions for the education of our masses, especially the peasantry, to grow up in every district. I remember the wonderful peasant museums I saw in the U.S.S.R., and compare them with the pitiful agricultural exhibitions that are organised here from time to time. I remember also vividly that splendid and astonishing museum, the Deutsches Museum at Munich, and wonder rather wistfully when some such thing will grow up in India.

It is for this Academy of Sciences to take a lead in all such matters and to advise the Government thereon. The Government should cooperate with them and help them and take full advantage of their expert knowledge. But the Academy must not just wait for the Government to give it a push every time. We have got too much into the habit of waiting for Government to take the initiative in every thing. It is the business of the Government to take the initiative, but it is also the business of the scientists to take the initiative themselves. We cannot wait for each other. We must get a move on.

And so, having taken up so much of your time, I commend you to your labours, and hope that you will have the privilege of serving India and of helping in the progress and advancement of her people.

MODERN DEVELOPMENTS IN THE SCIENCE OF SOIL AND PLANT NUTRITION

LECTURE, ILLUSTRATED BY LANTERN SLIDES, DELIVERED AT THE 7TH ANNUAL MEETING OF THE NATIONAL ACADEMY OF SCIENCES ON THE 5TH MARCH, 1938

BY B. VISWA NATH

IMPERIAL AGRICULTURAL RESEARCH INSTITUTE, NEW DELHI

In asking me to address this Annual Meeting of the Academy, our distinguished President, Professor Sahni, desired that the subject of my address should be one of my personal research and that it should be of national and practical interest. No apology is, therefore, needed if I make my main theme 'the rôle of organic matter in soil and plant nutrition', a subject of intense interest at the present moment. It is in itself a vast subject for a single lecture. I must therefore confine myself to one aspect of it which deals with substances which stimulate and regulate growth and development in plants. These substances are known as plant hormones, and the remarkable developments that have taken place in recent years are such as to revolutionise our views in plant physiology and chemistry and to necessitate a revision of our ideas in the nutrition of field crops.

For the proper appreciation of the development of this newer knowledge in the fields of plant chemistry and plant physiology, I must ask you to look back a century. Till about the year 1840, the humus theory of plant nutrition was in vogue and the view was held that plants should be nourished only by substances of a similar nature. In 1840, Liebig[7] analysed ashes of plants and manures and showed that plants could utilize and thrive on mineral salts. He attributed the effectiveness of farmyard manure or cattle manure to the mineral salts of potassium, phosphorous, sodium, magnesium and calcium contained in it—substances also found in plants. From the practical point of view this mineral theory of plant nutrition had simplified the problem of manuring crops. It was evident that all the constituents found in the ashes of plants need not always be supplied to the soil, and that it would be enough if the constituent indicated, by a chemical analysis of the soil, as inadequate or lacking was restored. The problem of soil and plant nutrition was so simple and scientifically convincing that it was a landmark and turning-point in the history of soil science and plant nutrition.

These ideas of chemical treatment of soil rapidly gained favour and flourished, and gave rise to the huge industry of artificial or chemical fertilisers. Ammonium sulphate, sodium nitrate, phosphates of calcium (superphosphates) and potash salts have found extensive use as fertilisers for all crops. In the earlier years, good crops could be obtained year after year by the use of artificial fertilisers only and

without the use of farmyard manure or cattle manure as was done before. It was, therefore, held that artificial and chemical fertilisers could substitute farmyard manure.

Subsequent experience has, however, shown this view to be wrong. From field experiments over long periods, it has been observed that although artificial fertilisers give larger yields in the beginning, they ultimately become lower than those obtained from farmyard manure.

It is further realised that farmyard manure, composts, green manures and other organic manures have in them something which cannot be explained in terms of nitrogen, phosphate, potash and humus they contained.

As farmyard manure and other organic manures were regaining their lost reputation, developments were taking place in the science of animal nutrition. The discovery of vitamins, with which we are familiar and which we understand as certain essential factors in the food of animals and human beings for growth, development and for the maintenance of health, opened up a new epoch and a new field of research in animal nutrition. Two important facts have been established in regard to the vitamins. One is that the animal kingdom depended on the plant kingdom for the supply of vitamins. The other is that vitamins found in animal products (*e.g.*, milk) and in animal tissues (*e.g.*, liver) have their origin in the plant world. For instance, the liver of the Cod Fish, which gives us the well-known Cod-liver oil which is prized for its vitamin A content, may be mentioned. Drummond and Zilva[5] (1922) have traced the source of vitamin A to the minute chlorophyllaceous diatoms which float on the surface layers of the sea.

Very little was known, if anything was known at all, of the origin of vitamins in plants. It was believed that the production of vitamins in plants is a characteristic feature of their metabolic activity. It was not recognised till recently that plants also required accessory nutritional factors for their growth, similar to vitamins for animals, although suggestions to that effect were made from time to time from the results of experiments with micro-organisms such as yeast, bacteria and fungi, which are members of the lower orders of the plant kingdom.

Wildiers[21] (1901) observed that yeast when inoculated into a medium containing inorganic salts and sugars did not grow and ferment until a substance which he termed *bios* was made available in the culture. This could be done either by extraneous additions or by liberation from the older and dead cells in the culture. This observation could not always be verified until Coping[4] (1929) had shown that only yeasts which were highly cultivated needed the addition of bios for their development on artificial and synthetic media, and that wild yeasts did not require this growth factor. Coping's results are of interest and significance in regard to the higher cultivated plants, which, as will be seen later, respond to the external supply of growth factors. Several investigators have subsequently recorded improvement in the growth of micro-organisms on the addition of vitamins or extracts known to contain vitamins.

Bottomley[3] (1914) and Mockeridge[10] (1917) were the first to make direct experiments and to observe the growth promoting effect of organic substances on higher plants. Their experiments were with aquatic plants in water cultures, in which they used small amounts of water extracts of bacterised peat and fermented manures. They considered that these extracts contained growth substances acting in a manner similar to vitamins for animals, and concluded that these growth-promoting substances which they called "*auximones*" (Gr. promoting growth) were as essential to plants as vitamins were for animals. Mockeridge[11] (1924) in a later communication, however, modified her views and abandoned the auximone theory.

Viswa Nath and Suryanarayana[17] (1927), in association with McCarrison, have gone a step further. They carried out their experiments with the important Indian food plants and under field conditions. They confirmed Bottomley's findings. In addition they demonstrated, for the first time, the existence of a cycle of growth factors in nature.

A very important and new observation made by Viswa Nath is that manurial and fertiliser applications are capable of reacting on plants not only by improving yields, but also by affecting the quality of the resulting seed. Using wheat and millet seeds raised separately with artificial fertilisers and cattle manure, a better crop was obtained from seeds raised with organic manures. Using the same seeds in experiments carried out in association with McCarrison, it was observed that the nutritional value of the crop was affected similarly. McCarrison found that the vitamins, essential for growth, were lower in grain from unmanured or chemical manured plots than in grain grown with organic manures. Other repeated experiments at Coimbatore and Pusa and by others elsewhere have corroborated these and have shown that the nutritive value of the crop is directly controlled by the organic manure used.

The observation that the same seed as has given higher nutritive value has also given a better seedling and plant, has been followed up. For example, the grain raised with organic manure was richer in some constituent that stimulated plant growth and also richer in vitamin. It appeared that the plant growth stimulant and vitamin might be either the same or at least interrelated, so that the stimulant would enable the plant to form vitamin. Experiments carried out with extracts of farm-yard manures and composts showed that with greater decomposition of the manure the amount of plant growth stimulants in the seed increased. Several other experiments with various fermented substances and yeast extracts produced stimulation in growth and flowering and seeding. From these and other experimental results, Viswa Nath suggested that micro-organisms are also concerned, and that the chain reaches from the bacteria at the start, through the organic matter and its plant stimulating substances, the vitamins produced in the plant, to the other end, namely, its utilisation by animal life, and finally going back to the soil, to go another round in

the chain. To put it briefly a new cycle, the growth factor cycle, micro-organisms *cum* organic matter-plant-animal-micro-organisms *cum* organic matter, has been defined.

In a later communication (1932) Viswa Nath[18] submitted further evidence and after a critical discussion of this and other data observed that the response to vitamins and the capacity to synthesise these appeared to be universal from the simplest unicellular organisms to the most complex multicellular animals, and reiterated that plants and bacteria do normally require auximones or vitamins and that if they can get them in a readily available form they utilize them and if not they exercise their powers of synthesis.

As would be expected, the new interpretation of the rôle of organic matter has not received universal acceptance. Although agricultural and horticultural investigators hold organic manures, particularly farmyard manure and composts, in high esteem, they were not prepared to accept the new view, as the transition from the realm of pure Chemistry into that of Biological Chemistry was sudden.

That was the position ten years ago. Between then and now, there has accumulated evidence which adds strength to Viswa Nath's hypothesis. At several places in and outside India, the effect of manurial treatment on the quality of the crop and its nutritive value has been confirmed and the connection between soil fertility and nutritive value of crop is growing stronger. Evidence is also forthcoming that a heavier crop does not always provide a larger food value. Neatby and McCalla[12] (1938) have shown that high-yielding varieties of wheat and barley have a marked tendency to be constitutionally low in protein content. These investigators consider that, while varieties characterised by moderately high yield and high protein content are known, it is doubtful whether in plant breeding the maximum possible yield can be combined with maximum possible protein.

Viswa Nath's hypothesis is also gathering strength on the theoretical or the purely scientific side. It would appear from a discussion[1] on 'growth factors' held by the Royal Society of London in the summer of 1937, that the position has been clarified and the existence of growth factors for plants has been recognised. Reporting the discussion in 'Nature',[1] that journal observes that the case established in the nutrition of animals is equally established in the nutrition of the most diverse varieties of cells; namely, that all cells from the lowliest bacterium to the cells of the highest animals are enabled to carry out the series of reactions leading to the production of energy and growth, only by the agency of other substances mostly of a nature akin to those already described in animal metabolism—vitamins.

Went (1927)[19] has shown that the growing tips of oat seedlings contained a substance possessing growth promoting properties. He called this substance *auxin* (Greek-increase). Since then innumerable investigators at several places reported auxins from several sources. Kögl[6] and his associates (1931—33) isolated auxins in a crystalline form from various sources such as urine, maize oil,

malt and yeast. Nehring[13] (1936) reported occurrence of these substances in the urine of pregnant mares. Their occurrence is reported in farmyard manure and liquid manure also.

At present three substances have been isolated from natural sources and their chemical characteristics have been studied. They are auxin A, auxin B and hetero-auxin. The first two are acids but possess different chemical structures. These are said to have been obtained from plants. The third, hetero-auxin, is identical with β-indole acetic acid and plants do not appear to contain this. It has been obtained from urine, certain moulds and yeasts. Owing to the existence of certain similarities in the action between animal hormones and auxins, the latter are called phytohormones or plant hormones. How far this nomenclature is justified remains to be seen.

The literature on auxins or phytohormones has developed rapidly and considerably. These have been shown to play a definite rôle in many life processes of plants such as cell division, plasmatic growth, cell extension or elongation. They are also shown to be concerned in photoperiodism, geotropism and in the regulation of the growth of plants in many ways. Indeed, the developments in this line have been so rapid that already several chemical substances have been prepared synthetically and these are reported to induce in plants physiological effects similar to the natural substances.

Kögl[6] (1938) in the course of a discussion on growth factors has suggested the existence of a cycle of growth substances in nature. He has illustrated the suggestion by an experiment in which neither *Polyporous adustus* nor *Nematospora gossypii* is able to grow in a synthetic medium; when inoculated together they develop. He considers that apparently *Polyporous* supplies biotin (of yeast), whilst *Nematospora* furnishes aneurin (vitamin B_1).

According to Bonner[2] (1937) and Robbins[15] (1937), aneurin (vitamin B_1) functions as a hormone of root growth. These workers find that, under normal conditions, the extremely small amounts of aneurin required for root growth are supplied by other parts of the plant. Without aneurin or its derivatives no root development is possible. This is suggestive that aneurin is the limiting factor for root development on cuttings. The work of Went[20] and associates (1938) provides support to this view in demonstrating that if aneurin is made available at the proper time root development is greatly increased in cuttings. Kögl[6] observes that we are induced to realise that aneurin (vitamin B_1), which is of such essential importance for the normal proceeding of the chemical processes inside the nerves, is also of physiological importance for the rice grain itself. Ramiah[14] (1938, private communication) has observed thicker aleurone layer in rice grains grown with organic manures.

The work of Thimman[16] (1934) and the more recent work of Link[8] (1937) and of Link[8] and associates (1937) indicates the rôle of micro-organisms as contributing factors for stimulating and regulating plant processes. Hetero-auxin has been

identified as a constituent of ether extracts of cultures of *Rhizobium phaseoli* (legume nodule forming organism). Link[9] (1937) in a later communication to 'Nature' brings forward evidence and has suggested that the beneficial effects of green-manuring, dung, urine, compost and humus soils may be due to hetero-auxin and similar substances.

This account, though brief, is enough to indicate the trend of modern research and thought in the field of soil and plant nutrition. It provides striking confirmation to the observation made by Viswa Nath and associates ten years ago. From the purely philosophical point of view, the evidence tends to reveal continuity and unity in the apparently discontinuous and diverse manifestations of nature. From the practical point of view, there is new knowledge and new outlook in the nutrition of soils and plants which may enable us to control the products of plant metabolism by suitable manuring for the benefit of animal and human nutrition. This is of particular importance in the case of Indian soils which are notoriously poor in organic matter. As regards crop plants, food crops especially, the observation of Coping[4] made earlier in this lecture in regard to highly cultivated yeasts, is of significance in the case of highly cultivated plants. In a country like India, where grain and in several cases single grain forms the bulk of the diet of the bulk of the population, it is obvious that reinforcement of the food value of the diet should be at the source. It does not necessarily follow that the largest crop is the best. A heavy crop lacking in vitamins and suitable proteins will have a lower food value than a lighter crop properly grown.

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VOTE OF THANKS

To Pandit Jawaharlal Nehru, Chairman of the Seventh Annual Meeting of the National Academy of Sciences, India, held on March 5, 1938

By M. N. Saha, D.Sc., F.R.S., and H. R. Mehra, Ph.D.

Proposing a vote of thanks to Pandit Jawaharlal Nehru, on behalf of the National Academy of Sciences, for accepting their invitation to preside over the annual function, Prof. M. N. Saha said :—

It was in the fitness of things that Pandit Jawaharlal has agreed to preside over this annual gathering of scientists in India. His position in the country can be described by a phrase which Americans use with respect to Abraham Lincoln: First in War, first in Peace, and next to Mahatma Gandhi, he occupies the first place in the hearts of his three hundred and fifty million countrymen. The time has now come for him to give a lead in peace-time work of reconstruction and consolidation of the country.

Both war and peace had got their own problems, but peace-time problems were more exacting than war-time ones. For blunder during war-time was to some extent inevitable and excusable but peace-time blunders were of more serious consequence to the nation. The Congress having accepted office, were face to face with peace-time problems. It seemed to him that their work of national reconstruction was being handicapped by some fetishes which they raised, probably as a war-time measure. But no progress could be made unless they got rid of those fetishes and attacked the problems from a realistic point of view. And science was not science if it hesitated to call a fetish other than a fetish, of which there were too many in this country. They would probably agree that in the reconstruction of the nation, science was to play a very significant part. The Government would have to devise ways and means for the organization of work for the production and distribution of the commodities needed for the sustenance of the nation and proper utilization and conservation of the nation's resources. The cooperation of scientists would be needed for that work. If scientific men and technicians did not exist for the development of any line of work, they had to be created out of the rising generations.

The first attempt at the organization of scientific life in these provinces was barely seven years old, when the National Academy of Sciences was started with the co-operation of the leading scientists of this province, and under the active and personal encouragement of the late Governor, Lord Hailey. It had not fulfilled all the ideals with which it started—in fact but for the reading of original papers and their publication, it had discharged very few of the functions of a National Academy. If it was to discharge those functions, it should not be merely an association of

scientists on a voluntary basis, but should be assigned a definite task, should be invested with proper authority, should have a permanent home and a permanent secretariat. Even if this Academy be not granted those rights and privileges, the national government would soon have to create another body with identical objects.

He thought that if the Academy was re-transformed, according to the ideas he had propounded, it could render as great a service as the Russian Academy of Sciences did for the reconstruction of Russia, or the Royal Society was doing for the maintenance of the industrial superiority of Great Britian.

Seconding the vote of thanks Dr. H. R. Mehra said:--

I have great pleasure in seconding the vote of thanks proposed by Dr. M. N. Saha. We have got amongst us today a great politician, who has taken the trouble to come here and encourage us by his presence.

APPENDIX 1

Abstract of the Proceedings

The Council resolved that Prof. N. R. Dhar and Prof. P. S. MacMahon be nominated to the council of the National Institute of Sciences of India for the year 1937 as Additional Vice-President and Additional Member respectively on behalf of the National Academy of Sciences, India.

The Council resolved that the size of the papers submitted for publication in the Proceedings of the National Academy of Sciences be limited to seven printed pages of the Proceedings.

The Council elected, as representatives of the Academy, Prof. S. S. Bhatnagar, D.Sc., O.B.E, F.N.I., Director, Chemical Laboratories, Punjab University, Lahore, and Mr. G. Chatterji, M.Sc., Meteorologist, Upper Air Observatory, Agra, to the Fiftieth Anniversary of the Foundation of the University of Allahabad.

The Council elected the following members to represent the Academy at the Silver Jubilee Session of the Indian Science Congress:—

The Hon'ble Sir S. M. Sulaiman, Kt., LL.D., F.N.I., Judge, Federal Court of India, New Delhi.

D. R. Bhattacharya, D.Sc., Ph.D., F.N.I., Professor of Zoology, Allahabad University, Allahabad.

A. C. Banerji, M.A., M.Sc., F.R.A.S., F.N.I., Professor of Mathematics, Allahabad University, Allahabad.

Shri Ranjan, D.Sc., Reader in Botany, University of Allahabad, Allahabad..

The following members were elected Fellows of the Academy in the Fellows' Meeting held on December 18, 1937.

G. R. Toshniwal, D.Sc., Physics Department, Allahabad University, Allahabad.

P. K. Sen Gupta, D.Sc., Professor of Physics, Rajaram College, Kolhapur (Bombay).

A. B. Misra, D.Sc., D Phil., Professor of Zoology, Hindu University, Benares.

Rajnath, Ph.D., Professor of Geology, Hindu University, Benares.

The following members were elected Office-bearers and Members of the Council of the Academy for the year 1938.

President

B. Sahni, D.Sc., Sc.D., F.R.S., F.N.I.

Vice-Presidents

D. R. Bhattacharya, D. Sc., Ph.D., F.Z.S., F.N.I

The Hon'ble Sir S. M. Sulaiman, Kt., M.A., LL. D., F.N.I.

HONY. TREASURER

H. R. Mehra, Ph.D., F.N.I.

GENERAL SECRETARIES

S. M. Sane, B Sc., Ph.D.
P. L. Srivastava, M.A., D. Phil., F.N.I.

FOREIGN SECRETARY

M. N. Saha, D.Sc., F.R.S., F.N.I.

MEMBERS OF THE COUNCIL

S. B. Dutt, D. Sc., P.R.S., F.N.I.
N. R. Dhar, D.Sc., F.I.C., I.E.S., F N.I.
J. A. Strang, M.A., B.Sc.
K. N. Bahl, DSc., D.Phil., F.N.I.
Shri Ranjan, D.Sc.
J. C. Ghosh, D.Sc., F.N.I.
A. C. Banerji, M.A., M.Sc., F.R.A.S., I.E.S., F.N.I.
Sam Higginbottom, Ph.D.
S. K. Banerji, D.Sc., F.N.I.

APPENDIX 2

Office Bearers and Members of the Council for the Year 1937

President

B. Sahni, D.Sc., Sc.D., F.R.S., F.N.I.

Vice Presidents

D. R. Bhattacharya, Ph.D., D.Sc., F.Z.S., F.N.I.
P. S. MacMahon B.Sc., M.Sc., F.I.C., F.N.I.

Hony. Treasurer

H. R. Mehra, Ph.D., F.N.I.

General Secretaries

S. M. Sane, B.Sc., Ph.D.
P. L. Srivastava, M.A., D.Phil., F.N.I.

Foreign Secretary

M. N. Saha, D.Sc., F.R.S., F.N.I.

Members of the Council

The Hon'ble Sir Shah Muhammad Sulaiman, M.A., LL.D., F.N.I.
N. R. Dhar, D.Sc., F.I.C., I.E.S., F.N.I.
George Matthai, Sc.D., I.E.S., F.N.I.
K. N. Bahl, D.Sc., D.Phil., F.N.I.
Shri Ranjan, D.Sc.
J. C. Ghosh, D.Sc., F.N.I.
C. W. B. Normad, D.Sc., F.N.I.
A. C. Banerji, M.A., M.Sc., F.R.A.S., I.E.S., F.N.I.
P. K. Parija, M.A., B.Sc., I.E.S., F.N.I.

APPENDIX 3

LIST OF MEMBERS

*—Denotes a fellow

†—Denotes a Fellow of the National Institute of Sciences of India

Date of Election		Alphabetical List of Members
31-10-35		Agarwal, Rai Amar Nath, Bari Kothi, Daraganj, Allahabad.
20-4-36	*	Ahmad, Ziauddin, D.Sc., Vice-Chancellor, Muslim University, Aligarh.
20-4-35	† *	Ajrekar, Shripad Lakshman, B.A., I.E.S., Professor of Botany, Gujarat College, Ahmedabad.
17-4-31	*	Asundi, R. K., Ph.D., Reader, Physics Department, Muslim University, Aligarh.
10-5-35	† *	Ayyangar, G. N. Rangaswami, Rao Bahadur, B.A., I.A.S., Millets Specialist to the Government of Madras, Agricultural Research Institute, P.O. Lawley Road, Coimbatore.
1-1-30	† *	Bahl, K. N., D. Phil., D.Sc., Professor of Zoology, Lucknow University, Lucknow.
1-1-30	† *	Banerji, A.C., M.A., M.Sc., F.R.A.S., I.E.S., Professor of Mathematics, Allahabad University, Allahabad.
29-2-32		Banerji, G.N., The Scientific Instrument Company, Ltd., Hornby Road, Bombay.
22-12-32	† *	Banerji, S. K., D.Sc., Meteorologist, Ganeshkhind Road, Poona 5
10-5-37		Bari, Abdul, M.Sc., Lecturer in Botany, Osmania University, Hyderabad, Deccan.
20-4-36	*	Basu, N.M., D.Sc., Bakshi Bazar, Dacca.
17-4-31		Basu, Saradindu, M.Sc., Meteorologist, Ganeshkhind Road, Poona 5.
31-10-35	† *	Bharadwaja, Yajnavalkya, Ph.D., Professor of Botany, Hindu University, Benares.
19-3-31	*	Bhargava, Saligram, M.Sc., Reader, Physics Department, Allahabad University, Allahabad.
17-4-31		Bhargava, Vashishta, M.Sc., I.C.S., Sessions and Subordinate Judge, Agra.
15-9-37		Bharucha, F.R., B.A., M.Sc., D.Sc., Professor of Botany, Royal Institute of Science, Bombay.

Date of Election		Alphabetical List of Members
17-4-31		Bhatia, K.B., I.C.S., Magistrate and Collector, Shahjahanpur.
17-12-35		Bhatia, M.L., M.Sc., Lecturer in Zoology, Lucknow University, Lucknow.
15-9-36		Bhatnagar, Birendra Kumar, B.Sc., 207 Mcdonnell University Hindu Hostel, Allahabad.
21-4-33	† *	Bhatnagar, S.S., D.Sc., O.B.E., Professor of Chemistry, Government College, Lahore.
10-5-37		Bhattacharya, Abani Kumar, M.Sc., Lecturer in Chemistry, Bareilly College, Bareilly.
20-12-34		Bhattacharya, A. K., D.Sc., Chemistry Department, Allahabad University, Allahabad.
17-4-31		Bhattacharya, D.P., M.Sc., Bareilly College, Bareilly.
1-1-31	† *	Bhattacharya, D.R., M.Sc., Ph.D., Docteur ès Sciences, Professor of Zoology, Allahabad University, Allahabad.
31-10-36	† *	Bose, D.M., M.A., B.Sc., Ph.D., Palit Professor of Physics, University College of Science and Technology, 92 Upper Circular Road, Calcutta.
20-4-36	*	Bose, N.K., Ph.D., Mathematical Officer, Irrigation Research Institute, Lahore.
20-4-36	† *	Burridge, W., D.M., M.A. (Oxon.), Professor of Physiology, Lucknow University, Lucknow.
1-2-36		Caleb, J., B.Sc., M.Sc., L.T., Biology Department, Ewing Christian College, Allahabad.
9-11-35		Chak, Chandramohan Nath, M.Sc., Professor of Education, Secondary Training College, Bombay.
31-10-35		Chakravarty, D. N., D.Sc., Professor of Chemistry, King Edward College, Amraoti, Berar.
10-5-35	† *	Champion, H. G., M.A., Sylviculturist, Imperial Forest Research Institute, Dehra Dun.
3-4-33		Chand, Tara, M.A., D.Phil., Principal, K.P. University College, Allahabad.
29-2-32		Charan, Shyama, M.A., M.Sc., Agra College, Agra.
17-4-31	*	Chatterji, A. C., D.Sc., Dr. Ing., Chemistry Department, Lucknow University, Lucknow.
1-1-30	† *	Chatterji, G., M.Sc., Meteorologist, Upper Air Observatory, Agra.
17-4-31	*	Chatterji, K.P., M.Sc., A.I.C., F.C.S., Reader, Chemistry Department, Allahabad University, Allahabad.
10-5-37		Chatterji, N.G., D.Sc., H.B. Technological Institute, Cawnpore.

Date of Election		Alphabetical List of Members
9-2-34		Chaturvedi, Pandit Champa Ram, Professor of Mathematics, St. John's College, Agra.
31-10-34	† *	Chaudhuri, H., M.Sc., Ph.D., D.I.C., Head of the Department of University Teaching in Botany, Punjab University, Lahore.
17-12-35		Chaudhury, K., Ahmad, M.Sc., Wood Technologist, Imperial Forest Research Institute, Dehra Dun.
19-3-31		Chaudhury, Rabindra Nath, M.Sc., M.A., Mathematics Department, Allahabad University, Allahabad.
10-5-37		Chaudhury, S. S., M.A., M.Sc., Kadam Kuan, P. O. Bankipore, Patna.
10-5-35	† *	Chopra, R. N., Lt.-Col., C.I.E., M.B., I.M.S., Director, School of Tropical Medicine, Central Avenue, Calcutta.
31-10-35		Dabadghao, V.M., Physics Department, College of Science, Nagpore.
1-2-37		Gandhy, Darabshaw J., Esq., Agricultural Institute, Naini, E. I. R. (Allahabad).
28-10-32	*	Das, A.K., D.Sc., Upper Air Observatory, Agra.
22-12-32	*	Das, B. K., D.Sc., Professor of Zoology, Osmania University, Hyderabad, Deccan.
19-3-31	*	Das, Ramsaran, D.Sc., Zoology Department, Allahabad University, Allahabad.
17-12-35	*	Das Gupta, S.N., M.Sc., D.I.C., Ph.D., Reader in Botany, Lucknow University, Lucknow.
29-7-36		Dass, A. T., Dharam, M.Sc., 13 Strachey Road, Allahabad.
20-4-36	† *	Datta, S., D.Sc., D.I.C., Professor of Physics, Presidency College, Calcutta.
15-9-37		Dayal, Jagadeshwari, M.Sc., Zoology Department, Lucknow University, Lucknow.
17-4-31	*	Deodhar, D.B., Ph.D., Reader, Physics Department, Lucknow University, Lucknow.
31-10-35	*	Desai, M. S., M.Sc., Professor of Physics, M.T.B. College, Surat.
29-2-32		Deb, Suresh Chandra, D.Sc., Research Physicist, Bose Institute, Calcutta.
17-4-31		Dey, P. K., M.Sc., I.A.S., Plant Pathologist to Government, United Provinces, Nawabganj, Cawnpore.
1-1-30	† *	Dhar, N. R., D.Sc., Docteur ès Sciences, F.I.C., I.E.S., Professor of Chemistry, Allahabad University, Allahabad.
31-10-35		Dube, Ganesh Prasad, M.Sc., Lecturer in Physics, Balwant Rajput College, Agra.

Date of Election		Alphabetical List of Members
23-4-37		Dubey, V. S., M.Sc., Ph.D., D.I.C., Professor of Economic Geology, Hindu University, Benares.
28-10-32		Dutt, A. K., D.Sc., Research Physicist, Bose Research Institute, Calcutta.
17-4-31	† *	Dutt, S. B., D.Sc., Reader, Chemistry Department, Allahabad University, Allahabad.
19-3-31		Dutt, S. K., M.Sc., Zoology Department, Allahabad University, Allahabad.
20-4-36	*	Ganguli, P. B., D.Sc., Professor of Chemistry, Science College, Bankipore P.O., Patna.
22-2-33		Ghatak, Narendranath, M.Sc., D.Sc., Chemical Assistant, Indian Stores Department, Government Test House, Alipore, Calcutta.
20-4-36	*	Ghosh, J., M.A., Ph.D., Professor of Mathematics, Presidency College, Calcutta.
8-11-33	† *	Ghosh, J. C., D.Sc., Professor of Chemistry, Dacca University, Dacca.
19-3-31	*	Ghosh, R. N., D.Sc., Physics Department, Allahabad University, Allahabad.
19-3-31	*	Ghosh, Satyeshwar, D.Sc., Chemistry Department, Allahabad University, Allahabad.
20-4-36	† *	Ghosh, S. L., Ph.D., Professor of Botany, Government College, Lahore.
31-10-35	*	Gulatee, B. L., M.A., Mathematical Advisor, Survey of India, Dehra dun.
17-4-31	*	Gupta, B. M., Ph.D., Deputy Public Analyst to Government, United Provinces, Lucknow.
10-5-37		Gupta, K. M., M.Sc., D.Sc., Professor of Biology, M. T. B. College, Surat.
17-4-31		Higginbottom, Sam, D. Phil., Principal, Allahabad Agricultural Institute, Naini, E. I. R., Allahabad.
10-5-37		Husain, M. Afzal, M.A., Principal, Agricultural College, Lyallpur (Punjab).
10-5-37		Husain, Qazi Mohammad, M.A., LL.B., Bar-at-law, Pro-Vice-Chancellor, Osmania University, Hyderabad, Deccan.
21-12-36		Husain, Zahur, B.A. (Hons.), c/o Prof. A.K. Nyazee, M.A., Superintendent, The 'Quadrangle' Hostel, Government College, Lahore.
10-5-37		Ishaq, Mohammad, Ph.D., Physics Deptt., Muslim University, Aligarh, U. P.

Date of Election		Alphabetical List of Members
20-4-36	*	John, C. C., Professor of Zoology, Agra College, Agra.
3-4-34		Joshi, A. D , P.E.S., Lecturer, Training College, Lucknow.
21-12-31	*	Joshi, S. S., D.Sc., Professor of Chemistry, Benares Hindu University, Benares.
10-5-37		Kalapesi, A. S., B.A., B.Sc., D.I.C., Ph.D., F.R.G.S., Professor, St. Xavier's College, Cruickshank Road, Fort, Bombay.
10-5-37		Khan, A. S., M.Sc., D.D.P.I., Bihar, 7 Strand Road, Patna.
15-9-31	† *	Kichlu, P. K., D.Sc., Department of Physics, Government College, Lahore.
21-4-33		Kishen, Jai, M.Sc., Professor of Physics, S.D. College, Lahore.
9-2-34	† *	Kothari, D. S., M.Sc., Ph.D., Professor of Physics, Delhi University, Delhi.
3-4-34	† *	Krishna, Shri, Ph.D., D.Sc., F.I.C., Forest Biochemist, Imperial Forest Research Institute, Dehra Dun.
5-10-33		Kureishy, A. M., M.A., Reader in Mathematics, Muslim University, Aligarh.
31-10-35		Lal, Rajendra Bihari, M.Sc., Assistant Traffic Superintendent, E.I.R., c/o Babu Basant Behari Lall, B.A., Partabgarh City (Oudh).
10-5-37		Mahabale, T. S., B.A., M.Sc., Deptt. of Biology, Gujarat College, Ahmedabad.
20-4-35	† *	Mahalanobis, P. C., M.A., I.E.S., Professor of Physics, Statistical Laboratory, Presidency College, Calcutta.
1-1-30	† *	MacMahon, P. S., B.Sc. (Hons.), M.Sc., Professor of Chemistry, Lucknow University, Lucknow.
15-9-37		Mahadevan, C., M.A., D.Sc., Assistant Superintendent, Hyderabad Geological Survey, Hyderabad (Deccan).
31-10-35	† *	Maheshwari, Panchanan, D.Sc., Botany Department, Allahabad University, Allahabad.
31-10-35		Majumdar, R. C., M.Sc., Ph.D., Bose Research Institute, 93 Upper Circular Road, Calcutta.
26-9-34		Malaviya, Braj Kishore, M.Sc., Public Health Department, Allahabad Municipal Board, Allahabad.
10-5-37		Mathur, A. P., M.Sc., D.I.C., D.Sc., Principal, Darbar Intermediate College, Rewa, C.I.
31-10-35	*	Mathur, K. N., D.Sc., Lecturer in Physics, Lucknow University, Lucknow.
31-10-35		Mathur, Lakshmi Sahay, M.Sc., Upper Air Observatory, Agra.

Date of Election		Alphabetical List of Members
15-9-31		Mathur, L.P., M.Sc., St. John's College, Agra.
8-11-33		Mathur, Ram Behari, M.Sc., Professor of Mathematics, St. Stephenson College, Delhi.
17-12-35	† *	Matthai, George, M.A., Sc.D., F.R.S.E., I.E.S., Professor of Zoology, Punjab University, Lahore.
19-3-31		Mazumdar, Kanakendu, D.Sc., Physics Department, Allahabad University, Allahabad.
1-1-30	† *	Mehta, K. C., Ph.D., M. Sc., Agra College, Agra.
19-3-31	† *	Mehra, H. R., Ph.D., Reader, Zoology Department, Allahabad University, Allahabad
16-8-35		Mehrotra, Braj Mohan, M.A., Ph.D., Mathematics Department, Benares Hindu University, Benares.
1-1-30	*	Mitter, J. H., M.Sc., Ph.D., Professor of Botany, Allahabad University, Allahabad.
23-4-37	*	Misra, Avadh Behari, D.Sc., D.Phil., Deptt. of Zoology, Benares Hindu University, Benares.
31-10-35		Mohan, Ananda, B.Sc., Assistant Traffic Superintendent, E.I.R., Chief Commercial Manager's Office, 105 Clive Street, Calcutta.
31-10-35		Mohan, Piare, M.Sc., Department of Mathematics, Allahabad University, Allahabad.
10-5-37		Moudgill, K. L., Principal, H. H. Maharaja's College of Science, Trivendrum (Travancore State).
20-4-35	† *	Mowdawalla, F. N., M.A., M I.E.E., Mem. A.I.E.E., M I E, Chief Electrical Engineer, Bangalore.
21-4-33		Mukerjee, Ashutosh, M A., Principal, Science College, P. O. Bankipore (Patna).
31-10-35		Mukerji, S., D.Sc., Kala Azar Enquiry, School of Tropical Medicine, Calcutta.
23-4-37		Mukerji, S.K., M.Sc., D.Sc., Professor of Physics, Agra College, Agra
15-9-37		Mundkur, B. B., M.A., Ph.D., Imperial Agricultural Research Institute, New Delhi.
1-1-30	*	Narayan, Luxmi, D.Sc., Reader, Mathematics Department, Lucknow University, Lucknow.
22-2-33	*	Narliker, V. V., M.A., Professor of Mathematics, Benares Hindu University, Benares.
23-4-37	*	Nath, Raj, D.I.C., Ph.D., Deptt. of Geology, Benares Hindu University, Benares.

Date of Election		Alphabetical List of Members
17-4-31	*	Nehru, S. S., M.A., Ph.D., I.C.S., Magistrate and Collector, Mainpuri, U. P.
20-4-35	† *	Normand, C. W. B., M.A., D.Sc., Director General of Observatories, Poona.
31-10-35		Oak, V. G., M.Sc., I.C.S., Joint Magistrate, Allahabad.
16-8-35		Pande, Kedar Dat, M.Sc., Government Intermediate College, Moradabad.
17-4-31	*	Pandya, K. C., Ph.D., St. John's College, Agra.
20-4-36	† *	Paranjpye, R. P., D.Sc., Vice-Chancellor, Lucknow University, Lucknow.
3-4-33	† *	Parija, P. K., M.A., I.E.S., Ravenshaw College, Cuttack.
10-5-35	† *	Pinfold, Ernest Sheppard, M.A., F.G.S., Geologist, Attock Oil Co. Ltd., Rawalpindi.
18-9-35	*	Pramanik, S. K., M.Sc., Ph.D., D.I.C., Meteorologist, Meteorological Office, Poona 5.
3-4-33		Prasad, Badri Nath, Ph.D., Docteur ès Sciences, Mathematics Department, Allahabad University, Allahabad.
5-10-33	*	Prasad, Gorakh, D.Sc., Reader in Mathematics, Allahabad University, Allahabad.
16-8-35		Prasad, Jalpa, M.Sc., Chemistry Department, K. P. Inter. College, Allahabad.
21-4-33	*	Prasad, Kamta, M.A., M.Sc., Professor of Physics, Science College, P. O. Bankipore (Patna).
15-9-31	† *	Prasad, Mata, D.Sc., Royal Institute of Science, Bombay.
10-5-37		Prasad, Shiva Parbati, M.A. (Cantab), Professor of Physics, Science College, Patna.
17-4-31		Puri, B. D., M.A., Thompson Civil Engineering College, Roorkee.
22-12-32	† *	Qureshi, M., M.Sc., Ph.D., Professor of Chemistry, Osmania University College, Hyderabad, Deccan.
10-5-37		Rahimullah, M., M.Sc., Lecturer in Zoology, Osmania University, Hyderabad.
10-5-37		Rahman, Wahidur, B.Sc. (Cal.), Professor of Physics, Osmania University, Hyderabad, Deccan.
20-12-34		Rai, Ram Niwas, M.Sc., Physics Department, Allahabad University, Allahabad.
15-9-37		Raina, Shyam Lal, M.Sc., Professor of Biology, S. P. College, Srinagar, Kashmir.

Date of Election		Alphabetical List of Members
21-4-33		Ram, Mela, M.Sc., Asst. Professor of Physics, Foreman Christian College, Lahore.
10-5-37		Ramiah, K., Geneticist and Botanist, Institute of Plant Industry, Indore.
3-4-33	*	Ram, Raja, M.A., B.E, Malarial Engineer, Kasauli.
23-4-37		Randhawa, M. S., I. C. S., Assistant Commissioner, Fyzabad
19-3-31	*	Ranjan, Shri, M.Sc. (Cantab), Docteur ès Sciences, Reader, Botany Department, Allahabad University, Allahabad.
15-9-31	*	Rao, A. Subba, D.Sc., Medical College, Mysore.
22-2-33		Rao, G. Gopala, B.A., M.Sc., D.Sc., Chemistry Department, Andhra University, Waltair.
21-12-31		Rao, D. H. Ramchandra, B.E., A.M.I.E., Engineer, Allahabad University, Allahabad.
20-4-35	*	Rao I., Rama Krishna, M.A., Ph.D., D.Sc., Department of Physics, Andhra University, Waltair.
14-3-34	†	Rao, K. Rangadharma, D.Sc., Physics Department, Andhra University, Waltair.
20-4-36	*	Rao, S. Ramchandra, M.A., Ph.D. (Lond), F. Inst P., Professor of Physics, Annamalai University, Annamalainagar P.O. (South India).
22-2-33	*	Ray, Bidhubhusan, D.Sc., 92 Upper Circular Road, Calcutta.
1-2-36		Ray, J. P., M.Sc., Professor, D.A.V. College, Dehra Dun.
10-5-37		Ray, Ramesh Chandra, D.Sc., F.I.C., Professor of Chemistry, Science College, Patna.
21-12-31		Ray, Satyendra Nath, M.Sc., Physics Department, Lucknow University, Lucknow.
23-4-37		Rode, K. P., M.Sc., Asst. Professor of Geology, Benares Hindu University, Benares.
29-2-32		Saha, Jogendra Mohan, M.Sc., Manager, Sitalpur Sugar Works, P.O. Dighwara, Dist. Saran.
1-1-30	† *	Saha, M.N., D.Sc., F.R.S., F.A.S.B., F. Inst. P., P.R.S., Prof. of Physics, Allahabad University, Allahabad.
1-1-30	† *	Sahni, B., D.Sc., Sc.D., F.R.S., F.G.S., F.A.S.B., Professor of Botany, Lucknow University, Lucknow.
17-4-31	*	Sane, S.M., B.Sc., Ph.D., Reader, Chemistry Department, Lucknow University, Badshah Bagh, Lucknow.
1-2-36	*	Saxena, Ram Kumar, D.Sc., Lecturer in Botany, Allahabad University, Allahabad.

Date of Election		Alphabetical List of Members
2-3-37		Schroff, M.L., B.A., M.S. (Mass), Head of the Department of Pharmaceutical Chemistry, Benares Hindu University, Benares.
10-5-37		Sayeeduddin, M., M.A., B.Sc., Professor of Botany, Osmania University, Hyderabad, Deccan.
31-10-35	† *	Sen, Jitendra Mohan, M. Ed., B.Sc., Teacher's Dip., F.R.G.S., D.Ed., Assistant Director of Education, Bengal, Calcutta.
3-4-33	*	Sen, K. C., D.Sc., Officer-in-charge, Animal Nutrition Section, Imperial Veterinary Research Institute, Izatnagar, U. P.
20-4-35	† *	Sen, Nikhil Ranjan, D.Sc., Professor of Mathematics, 92 Upper Circular Road, Calcutta.
17-12-35	† *	Sen Gupta, N. N., Ph.D., Professor of Psychology, Lucknow University, Lucknow.
20-12-34	*	Sen Gupta, P. K., D.Sc., Professor of Physics, Rajaram College, Kolhapur, Bombay Presidency.
21-4-33	*	Seth, J. B., M.A., Government College, Lahore.
17-4-31		Seth, S. D., M.Sc., Christ Church College, Cawnpore.
10-5-37		Seth, Trilok Nath, M.Sc., Ph.D., Lecturer and Head of the Department of Medical Chemistry, Medical College, Patna.
19-3-31	*	Sethi, Nihal Karan, D.Sc., Agra College, Agra.
23-4-37		Sethi, D. R., Esq., I.A.G., Director of Agriculture, Bihar, Patna.
31-10-35		Shabde, N. G., D.Sc., Professor of Mathematics, College of Science, Nagpur.
10-5-37		Sharma, Dhyan Swarup., B.Sc., 1 & 2 Roxy Hotel, University Road, Allahabad.
31-10-35		Sharma, P.N., M.Sc., Physics Department, Lucknow University, Lucknow.
15-9-31		Sharma, Ram Kishore, M.Sc., Physics Department, Ewing Christian College, Allahabad.
18-9-35		Shukla, Janardan Prasad, M.Sc., Manufacturing Chemist, Oudh Sugar Mills, Hargaon (R.K.Ry.), U.P.
3-4-33	† *	Siddiqi, M.R., Ph.D., Professor of Mathematics, Osmania University, Hyderabad, Deccan.
3-4-33	*	Siddiqui, Mohammad Abdul Hamid, M.A., M.S., F.R.C.S., D.L.O., Professor of Anatomy, King George's Medical College, Lucknow.
10-5-37		Singh, Bawa Kartar, Sc.D., I.E.S., Professor of Chemistry, Science College, Patna.

Date of Election		Alphabetical List of Members
17-12-35	*	Singh, Bhola Nath, D.Sc., Kapurthala Professor of Agricultural Botany and Plant Physiology, Head of the Institute of Agricultural Research, Hindu University, Benares.
10-5-37		Singh, T. C. N., D.Sc., Asst. Economic Botanist, In-charge Botanical Section, Sabour (Bihar).
17-4-31		Soonawala, M.F., M.Sc., Maharaja's College, Jaipur (Rajputana).
18-9-35		Srivastava, Bishwambhar Nath, M.Sc., Lecturer, Physics Department, Allahabad University, Allahabad.
25-3-36		Srivastava, Har Dayal, M.Sc., Offg. Helminthologist, Imperial Institute of Veterinary Research, Muktesar.
19-3-31	† *	Srivastava, P.L., M.A., D. Phil., Reader, Mathematics Department, Allahabad University, Allahabad.
10-8-33	*	Srivastava, R.C., B.Sc. (Tech.), Sugar Technologist, Imperial Council of Agricultural Research, India, Cawnpore.
15-9-31	*	Shrikantia, C., B.A., D.Sc., Medical College, Mysore.
19-12-32	*	Strang, J.A., M.A., B.Sc., Professor of Mathematics, Lucknow University, Lucknow.
17-4-31	† *	Sulaiman, S. M., Hon'ble Sir, Judge, Federal Court of India, Delhi.
20-4-36	*	Sur, N.K., D.Sc., Meteorologist, Meteorological Department, Poona.
19-3-31		Taimini, Iqbal Kishen, Ph.D., Chemistry Department, Allahabad University, Allahabad.
17-12-35		Tandon, Amar Nath, M.Sc., D.Phil., Physics Department, Allahabad University, Allahabad.
9-11-35		Tandon, Prem Narain, M.Sc., I.C.S., Joint Magistrate, Gaya, Bihar.
15-9-37		Thapur, G. S., Ph.D., Reader in Zoology, Lucknow University, Lucknow.
23-4-37		Tiwari, N. K., M.Sc. (Alld.), Asst. Professor of Botany, Benares Hindu University, Benares.
19-3-31	*	Toshniwal, G.R., M.Sc., D.Sc., Physics Department, Allahabad University, Allahabad.
15-9-36		Trivedi, Hrishikesh, M.Sc., D.Sc., Physical Assistant, Government Test House, Judge's Court Road, Alipur (Calcutta).
3-4-34		Varma, Rama Shanker, M.Sc., Christ Church College, Cawnpore.
20-12-34		Varma, S.C., M.Sc., Zoology Department, Allahabad University, Allahabad.

Date of Election		Alphabetical List of Members
9-2-34		Vaugh, Mason, B.Sc. (Ing.), Agricultural Engineer, Allahabad Agricultural Institute, Naini (E.I.Ry.) (Allahabad).
2-3-37		Vestal, Edgar F., Ph.D., Botany Section, Agricultural Institute, Naini, E.I.R.
19-3-31	† *	Vijayaraghavan, T., D. Phil., Reader, Mathematics Department, Dacca University, Ramna, Dacca.
20-4-35	† *	Vishwanath, B., Rao Bahadur, F.I.C., Offg. Director, Imperial Agricultural Research Institute, New Delhi.
20-4-35	† *	Wadia, D.N., M.A., B.Sc., F.G.S., F.R.G.S., Geological Survey of India, 27, Chowringhee, Calcutta.
1-1-30	† *	Wali, Mohammad, Ch., M.A., Ph.D., I.E.S., Professor of Physics, Lucknow University, Lucknow.

N.B.—The Secretaries will be highly obliged if the members will kindly bring to their notice errors, if there be any, in their titles, degrees, and addresses.

APPENDIX 4

List of Exchange Journals

INDIAN

Publishers	Journals
ALLAHABAD	
Mu Pi Omega Society	Proceedings of the Mu Pi Omega Society
BANGALORE	
The Indian Academy of Sciences	Proceedings of the Indian Academy of Sciences, Section A
"	" Section B
The Indian Institute of Science	Journal of the Indian Institute of Science, Section A
"	" Section B.
"	Current Science
Department of Electrical Technology, Indian Institute of Science	Electrotechnics
Society of Biological Chemists, India	Proceedings of the Society of Biological Chemists, India
BOMBAY	
Haffkine Institute	Report of the Haffkine Institute
CALCUTTA	
Asiatic Society of Bengal	Journal of the Asiatic Society of Bengal (Letters)
"	Journal of the Asiatic Society of Bengal (Science)
"	Year Book
"	Journal and Proceedings of the Asiatic Society of Bengal
National Institute of Sciences of India	Transactions of the National Institute of Sciences of India
"	Indian Science Abstracts
"	Proceedings of the National Institute of Sciences of India
"	Report of the Council of the National Institute of Sciences of India
Indian Association for Cultivation of Science	Indian Journal of Physics and Proceedings of the Indian Association for the Cultivation of Science

Publishers	Journals
CALCUTTA	
Bose Research Institute	Transactions of the Bose Research Institute
Indian Science News Association	Science and Culture
Indian Chemical Society	The Journal of the Indian Chemical Society
Oxford University Press	Indian Physico-Mathematical Journal
COONOR	
Nutrition Research Laboratories	Publications of the Laboratories
MADRAS	
Department of Fisheries	Journals, Administration Report
Madras Government Museum	Bulletin of the Madras Government Museum, Natural History Section
NEW DELHI	
Industrial Research Bureau	Bulletin of the Indian Industrial Research
Imperial Council of Agricultural Research	Indian Journal of Agricultural Science
"	Indian Journal of Veterinary Science and Animal Husbandry
"	Scientific Monographs of the Imperial Council of Agricultural Research
"	Agriculture and Livestock in India
NAGPUR	
Nagpur University	Nagpur University Journal
HYDERABAD (DECCAN)	
Osmania University	Journal of the Osmania University
PATNA	
Philosophical Society, Patna Science College	Bulletin of the Patna Science College Philosophical Society
POONA	
Indian Meteorological Department	Scientific notes
"	Memoirs of the Indian Meteorological Department

FOREIGN

Publishers	Journals
AUSTRALIA	
ADELAIDE	
The Royal Society of South Australia	Transactions of the Royal Society of South Australia
EAST MELBOURNE	
Council for Scientific and Industrial Research	Journal of the Council for Scientific and Industrial Research
"	Pamphlet of the Council for Scientific and Industrial Research
"	Annual Report
Radio Research Board, Council for Scientific and Industrial Research	Bulletin of the Radio Research Board
MELBOURNE	
Royal Society of Victoria	Proceedings of the Royal Society of Victoria
SYDNEY	
Royal Society of New South Wales	Journal and Proceedings of the Royal Society of New South Wales
AUSTRIA	
VIENNA	
Akademie der Wissenschaften	Anzeiger (Mathematisch-naturwissenschaftliche Klasse)
"	Anzeiger (Philosophisch-historische Klasse)
"	Almanach
BELGIUM	
BRUSSELS	
L'Academie Royale de Belgique	Bulletin de la Classe des Sciences
"	Annuaire de l'Academie Royale de Belgique
BRAZIL	
RIO DE JANEIRO	
Instituto Oswaldo Cruz	Memorias do Instituto Oswaldo Cruz

Publishers	Journals
CANADA	
OTTAWA	
The Royal Society of Canada	Transactions of the Royal Society of Canada
The National Research Council	Annual Report
TORONTO	
The Royal Astronomical Society of Canada	Journal of the Royal Astronomical Society of Canada
VICTORIA	
The Dominion Astrophysical Observatory	Publications of the Dominion Astrophysical Observatory
CHINA	
NANKING	
National Research Institute of Biology, Academia Sinica	Sinensia
Zoological Society of China, Academia Sinica	Chinese Journal of Zoology
National Research Institute of Chemistry, Academia Sinica	Memoir of the National Research Institute of Chemistry
SHANGHAI	
National Research Institute of Physics, Academia Sinica	Scientific Papers of the National Research Institute of Physics
DENMARK	
COPENHAGEN	
Det Kgl. Danske Videnskabernes Selskab.	Mathematisk-fysiske Meddelelser
"	Biologiske Meddelelser
L'Académie Royale des Sciences et des Lettres de Denmark	Mémoires de l'académie Royale des Sciences et des Lettres de Denmark
Laboratoire Carlsberg	Comptes-Rendus des Travaux du Laboratoire Carlsberg
EGYPT	
CAIRO	
The Egyptian Medical Association	Journal of the Egyptian Medical Association

Publishers	Journals
ENGLAND	
ABERDEEN	
Imperial Bureau of Animal Nutrition	Technical Communications
ABERYSTWYTH	
Imperial Bureau of Plant Genetics, Herbage Plants,	Bulletins
ST. ALBANS, HERTS	
Imperial Bureau of Agricultural Parasitology	Helminthological Abstracts
"	Bibliography of Helminthology
CAMBRIDGE	
Imperial Bureau of Plant Genetics, School of Agriculture	Plant Breeding Abstracts
The Philosophical Society	Proceedings of the Cambridge Philosophical Society
EDINBURGH	
The Royal Society of Edinburgh	Proceedings of the Royal Society of Edinburgh
HARPENDEN	
Imperial Bureau of Soil Science, Rothamsted Experimental Station	Technical Communications
"	Reprints
"	Reports
EAST MALLING, KENT	
Imperial Bureau of Fruit Production	Horticultural Abstracts
LONDON	
The Electrician, Bouverie House	Electrician
TEDDINGTON, MIDDLESEX	
The National Physical Laboratory	Reports of the National Physical Laboratory
"	Collected Researches of the National Physical Laboratory

Publishers	Journals
KYOTO	
Physico-chemical Society of Japan, Kyoto Imperial University	Review of Physical Chemistry of Japan
OSAKA	
The Faculty of Science, Osaka Imperial University	Collected Papers from the Faculty of Science
SAPPORO	
The Faculty of Science, Hokkaido Imperial University	Journal of the Faculty of Science, Series I, Mathematics
SENDAI	
Imperial University of Tohoku	Science Reports of the Tohoku Imperial University
TOKYO	
The Imperial Academy	Proceedings of the Imperial Academy
The Institute of Physical and Chemical Research	Scientific Papers
The National Research Council of Japan	Japanese Journal of Mathematics
"	Japanese Journal of Botany
"	Japanese Journal of Physics
"	Japanese Journal of Astronomy and Geophysics
"	Report
"	Report of Radio Research
The Physico-Mathematical Society of Japan	Proceedings of the Physico-Mathematical Society of Japan

Manchoukuo

HSHINCHING	
The Institute of Scientific Research	Report of the Institute of Scientific Research

Philippine Islands

MANILA	
Bureau of Sciences, Department of Agriculture and Commerce	Philippine Journal of Science

Publishers	Journals
POLAND	
CRACOVIE	
Académie Polonoise des Sciences et des Letters	Comptes Rendus Mensuels des Séances de la classe des Sciences Mathématiques et Naturelles
"	Comptes Rendus Mensuels des Séances de la classe de Médicine
"	Bulletin International, class des Sciences Mathématiques et Naturelles. Śerie A: Sciences Mathématiques
"	Bulletin International, classe des Sciences Mathématiques et Naturelles. Śerie B: Sciences Naturelles (I)
"	Bulletin International, classe des Sciences Mathématiques et Naturelles Śerie B: Sciences Naturelles (II)
"	Memoires, classe des Sciences Mathématiques et Naturelles, Śerie A: Sciences Mathématiques
"	Memoirs, classe des Sciences Mathématiques et Naturelles, Śerie B: Sciences Naturelles
"	Bulletin International, classe de Médecine
"	Memoires classe de Médecine
Polska Akademja Umiejetności	Starunia
WARSAW	
Société des Sciences et des Lettres de Varsovie	Comptes Rendus des Śeances, class I (jezykoznawstwa i historji literatury)
"	Comptes Rendus des Śeances, class II (historycznych, spolecznych i filozoficznych)
"	Comptes Rendus des Śeances, class III (matematyczno-fizycznych)
"	Comptes Rendus des Śeances, class IV (bilogicznych)
Polish Physical Society	Acta Physica Polonica

Publishers	Journals
New Zealand	
WELLINGTON	
Royal Society of New Zealand	Transactions and Proceedings of the Royal Society of New Zealand
South Africa	
CAPE TOWN	
Royal Society of South Africa	Transactions of the Royal Society of South Africa
Sweden	
LUND	
Kungl. Fysiografiska Sällskapets	Kungl. Fysiografiska Sällskapets Forhandlingar
STOCKHOLM	
Kungl. Svenska Vetenskapsakademie	Kungl. Svenska Vetenskapsakademiens Handlingar
UPPSALA	
Uppsala Universitet	Uppsala Universitets Årsskrift
Switzerland	
GENEVA	
Société de Physique et d' Histoire Naturelle de Genève	Compte Rendu des Séances de La Société de Physique et d' Histoire Naturalle de Genève
United States of America	
ALLEGHENY CITY	
Allegheny Observatory of the University of Pittsburgh	Publications of the Allegheny Observatory
BOSTON	
American Academy of Arts and Sciences	Proceedings of the American Academy of Arts and Sciences
"	Memoirs of the American Academy of Arts and Sciences

Publishers	Journals
CALIFORNIA	
The Mount Wilson Observatory	Contributions from the Mount Wilson Observatory
„	Communications from the Mount Wilson Observatory
„	Report of the Director of the Mount Wilson Observatory
University Library	Publications in Zoology. University of California
Lick Observatory, University of California	Lick Observatory Bulletin
CAMBRIDGE MASS.	
Massachusetts Institute of Technology	Journal of Physics and Mathematics
CHICAGO	
The University of Chicago	Astrophysical Journal
LAWRENCE, KANSAS	
The University of Kansas	Science Bulletin
MICHIGAN	
Observatory Library, University of Michigan	Publications of the Observatory of the University of Michigan
NEW YORK	
Bell Telephone Laboratories	Bell Telephone System Technical Publications
American Telephone and Telegraph Company	Bell System Technical Journal
Roosevelt Wild Life Forest Experiment Station	Roosevelt Wild Life Annals
The American Museum of Natural History	American Museum Novelties
New York Academy of Sciences	Annals of the New York Academy of Sciences
American Institute of Physics	Review of Scientific Instruments
„	Journal of Chemical Physics

Publishers	Journals
NEW HAVEN, YALE	
Astronomical Observatory of Yale University	Transactions of the Astronomical Observatory, Yale University
Secretary, American Journal of Science	American Journal of Science
PHILADELPHIA	
The Franklin Institute of the State of Pennsylvania	Journal of the Franklin Institute
American Philosophical Society	Proceedings of the American Philosophical Society
Academy of Natural Sciences	Proceedings of the Academy of Natural Sciences of Philadelphia
,,	Miscellanea
,,	Library Annual Report
WOODS HALE, MASS.	
Marine Biological Laboratory Library	The Biological Bulletin
WASHINGTON	
The National Academy of Sciences	Proceedings of the National Academy of Sciences
Smithsonian Institute	Publications
Department of Commerce, Bureau of Standards	Publications of the Bureau of Standards
The Commissioner of Fisheries	Publications

United States of Soviet Russia

Publishers	Journals
KHARKOV	
Chaikovsakaya 16	Physikalische Zeitschrift der Sowjet-Union
LENINGRAD	
The Akademie der Wissenschaften	Bulletin de l'Academie des Sciences Mathématiques et Naturelles
MOSCOW	
De l'Académie des Sciences de l'URSS	Comptes Rendus (Doklady)
,,	Bulletin de l'Académie des Sciences de l'URSS classe des Sciences Mathématiques et Naturelles

Publishers	Journals
UKRAINE	
Academie des Sciences d'Ukraine, Kyiv	Journal du Cycle Physique et de Chemie
"	Journal du Cycle Mathématique
"	Bulletin de la classe des Sciences Physiques et Mathématiques

APPENDIX 5

Journal subscribed by the National Academy of Sciences, India, during the year 1937.

General

Hirschwaldsche Buchhandlung, Berlin, N. W. 7	Die Naturwissenschaften

APPENDIX 6

LIST OF PAPERS READ BEFORE THE ACADEMY DURING JANUARY, 1937—DECEMBER, 1937

1. On the Convergence of the Conjugate series of the derived Fourier Series by P. L. Bhatnagar, Allahabad University.
2. Similarity between Carbon-assimilation and Nitrogen fixation by N. R. Dhar, E. V. Seshacharyulu and S. K. Mukerji, Allahabad University.
3. On the Electron Affinity of Bromine by A. N. Tandon, Allahabad University.
4. Reflection of Radiowaves from the Ionosphere by Ram Ratan Bajpai, Allahabad University.
5. On the Absorption Spectra of the Monosulphides of Alkaline Earth Elements and their Latent Heats of Vaporisation by L. S. Mathur, Allahabad University.
6. Nitrogen fixation and Azotobacter count on the application of Carbohydrates and other energy-rich materials to the soil, Part III, by N. R. Dhar and E. V. Seshacharyulu, Allahabad University.
7. Changes in soil nitrogen after the addition of fresh cowdung to the soil by S. K. Mukerji, Allahabad University.
8. The alimentary canal of Coccinella septem punctata by S. Pradhan, Lucknow University.
9. Fossil plants from the Intertrappean beds at Mohgaon Kalan (C. P.) by B. Sahni, Lucknow University, and K. P. Rode, Benares Hindu University.
10. The Lattice Energy of some Alkali Iodides and the Electron Affinity of Iodine by A. N. Tandon, Allahabad University.
11. Two new Fish Trematodes from Allahabad by B. P. Pande, Allahabad University.
12. Chemical examination of the seeds of Isabghol, Plantago ovata Forks by G. P. Pendse, Victoria College, Gwalior.
13. On the Salivary glands in the Order Coleoptera, Part I. The Salivary glands in the Family Tenebrinoideae by R. L. Gupta, Lucknow University.
14. New stregeids (Trematoda) from Indian birds by R. D. Vidyarthi, Allahabad University.
15. On Parachor and Thermal conductivities of Metallic elements by Binayendra Nath Sen, Burdwan Raj College, Burdwan.
16. The Inverse Square Law, a demonstration by Saiyid Muhammad Muqtagir, Mu Pi Omega Society, Allahabad.

17. Fungi of Mussoorie by J. H. Mitter and R. N. Tandon, Allahabad University.
18. The Mathematical Theory of a New Relativity, Chapter XV. The Rotational Theory of Light and Matter by the Hon'ble Sir Shah Muhammad Sulaiman, Chief Justice, Allahabad.
19. Prosotocus himalayai, n.sp., a frog trematode (Lecithodendriidae) by B. P. Pande, Allahabad University.
20. On an Equation for the Viscosity of mixtures by S. K. Chakravarti and P. B. Ganguly, Science College, Patna.
21. Action of Para-toluene-sulphonyl chloride on Phenols containing Azo groups by A. B. Sen, Lucknow University.
22. Ionisation of F-Region before Sunrise by K. B. Mathur, Allahabad University.

APPENDIX 7

Financial Statement from January 1, 1937 to December 31, 1937

Receipt	Rs.	a.	p.	Expenditure	Rs.	a.	p.
Opening Balance on 1st January, 1937	178	8	0	Establishment	1,149	0	0
Subscription from Members	3,194	0	0	Honorarium to the Assistant Editor	150	0	0
Grant from the Government, United Provinces ...	2,000	0	0	Contingency (including printing, postage stamps, stationery, allowance, etc.)	840	9	0
Grant from the Allahabad Municipal Board ...	80	0	0	Printing of the Proceedings of the National Academy of Sciences, India	2,010	6	9
Donation	200	0	0	Binding of Journals	103	12	0
Sale of the Proceedings of the National Academy of Sciences, India	39	4	0	Subscription of Journal for 1935, 1936 and 1937 ...	140	13	0
Bank Commission on outside cheques	2	0	0	Furniture	96	0	0
				Bank Commission on outside cheques	20	4	0
				Available Cash balance on 31st December, 1937, with the Imperial Bank of India	1,182	15	3
Total Rs. ...	5,693	12	0	Total Rs. ...	5,693	12	0

Accounts compiled by :—

P. C. Mukerji,
Office of the National Academy of Sciences, India

H. R. Mehra,
Ph.D. (Cantab)
Hony Treasurer,
National Academy of Sciences, India.

ADDRESS OF THE PRESIDENT

In welcoming the distinguished visitor the President of the Academy, Prof. B. Sahni, made the following remarks :

LADIES AND GENTLEMEN,

It is with no ordinary pleasure that I welcome, on behalf of the Academy, our distinguished visitor, Pandit Jawaharlal Nehru. That the erstwhile President of the Indian National Congress should have agreed to preside over the annual meeting of the National Academy of Sciences is a happy sign of the times. His visit to us at the present time is particularly opportune. In this period of rapid transition we most need contact with those, like him, who have a synthetic outlook on things. For, although the politician and the scientist are governed by different codes of discipline, the ultimate aim of both is the same : freedom through self-expression. And, of course, the spirit of Science is of the very essence of independence.

But between politics and Science there is this important difference that Science, with all its tradition of discipline, is nevertheless essentially a school of unfettered thought where authority, as mere authority, counts for nothing. In a sense, therefore, Science, if it does not directly foster, is at any rate not averse to the mentality of the heretic or of the rebel—even of the revolutionary—by which I mean, in the widest sense, the mentality of the man who ventures the untrodden path. And, after all, who can say that this mentality of the rebel or of the heretic is not absolutely essential to human progress ?

Professor Sahni then delivered his address.

REVOLUTIONS IN THE PLANT WORLD

PRESIDENTIAL ADDRESS DELIVERED AT THE ANNUAL MEETING OF THE ACADEMY HELD ON SATURDAY, MARCH 5, 1938

BY B. SAHNI, M.A., D.SC., SC.D., F.R.S.
PROFESSOR OF BOTANY, UNIVERSITY OF LUCKNOW

As the subject of my address today I have chosen a small theme embraced by that ocean of ideas that we call evolution. The particular aspect that I propose to deal with is Revolutions in the Plant World.

As in the history of nations, so also in that of plants and animals, we find that after a period of gradual change, which we generally call evolution, there comes inevitably a revolution—a period of rapid transition, when the balance of relations

becomes upset and things begin to move faster and on a different plane. It would almost seem as if the very conditions that at first retard progress serve, in time, to bring about an acceleration, like the sediments that dam up the course of a river which some day must burst its banks to find a freer outlet for its pent up waters.

These revolutions in the organic world are the landmarks of geological history. Each of them marks a large-scale extinction of plant and animal life as well as a more or less sudden appearance of forms of life previously unknown. So striking is this fact of the sudden appearance of new species, genera and families that it is in sharp conflict with the Darwinian doctrine of natural selection as the only or even the chief explanation for the origin of new forms of life. Evolution in the sense of a gradual, orderly process of change is an undisputed fact. But evolution in this gradual sense is not the whole of organic evolution as revealed by the geological record. Periodic revolutions are an integral and essential part of evolution, and it may well be that they form the more important part, so far as the creation of new forms is concerned. At all events the orthodox idea of natural selection through the gradual accumulation of continuous variations utterly fails to explain some of the glaring facts of palaeontology.

The Major Revolutions in the Plant World

I am not referring here to mutations in individual species, but to transformations on a large scale, affecting a whole flora or fauna, such as we find when we trace the history of plant and animal life through geological time. The facts have been reviewed more than once by such eminent palaeobotanists as the late Dr. D. H. Scott and Professor Sir Albert Seward. Speaking in broad terms, there were four or five such major revolutions, which Professor Seward has aptly called 'nodal points in the history of evolution'.[1]

(*i*) The first appearance of vascular plants must have marked a tremendous advance in the history of plant life. The date of this important event is still unknown but some early members of this land flora have been traced back to the Silurian period. An essentially similar type of vegetation seems to have continued through the Lower and Middle Devonian. (*ii*) But then a widespread change ushered in the flora which is familiar to us in the coal measures of Europe and America. This flourished during the Later Devonian, Carboniferous and Permian times. Till after the end of the Middle Carboniferous this Palaeozoic vegetation was fairly uniform in the northern and southern hemispheres. (*iii*) But in the Late Carboniferous and Permian floras we find a sharp contrast between the north and the south. The original southern flora was mostly killed out by a climatic

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[1] Seward (1923), p. lxix.

revolution and there emerged a unique type of vegetation, the so-called *Glossopteris* flora, of which the origin has always been a great puzzle. We cannot call this change, great as it was, a worldwide transformation, but it was certainly one of the major events in the evolution of the plant world. We may conveniently speak of it as the Gondwana revolution, after the southern Gondwana continent on which the new flora mysteriously made its appearance. (*iv*) With the end of the Permian or early Trias the sharp contrasts between the northern and southern provinces disappeared. We find the essentially Palaeozoic flora, with its dominant seed ferns, Cordaiteae, giant lycopods and calamites now giving place to a more modern type of vegetation. Conifers and cycads are now much more prominent, while among the ferns several modern families can be recognized. The change is so abrupt that it threatens to shake one's faith in the doctrine of continuity in evolution. (*v*) The last great transformation came—or, to be more correct, became evident—in the early Cretaceous. As is the case with all revolutions, its beginnings must have been much earlier than its outward manifestation. We are now introduced to a new flora, essentially similar to that which we see today, with flowering plants as the dominant race. The early Cretaceous angiosperms are quite modern in their structure, and distinct from any known in the older rocks. In spite of much recent work tending to trace the origin of the angiosperms to the earlier strata the gap remains essentially unbridged: of real links with the Jurassic we know very few.

These are, briefly, the main landmarks in the history of plant life; and similar 'nodal points' are seen in the fossil history of animals.

Breaks in the Life-lines: Are they Real or Apparent?

These revolutions in the organic world are one of the most striking revelations of palaeontology, as they still remain one of its greatest riddles. The question is, Will these gaps in the record be ever filled up by further research, or are they real breaks in the life-lines of the plant kingdom? Is the earth's crust a book of which pages here and there have been torn out and lost, or is it that these pages never existed, and we have to seek elsewhere for an explanation of the gaps in the story?

To some extent, no doubt, the suddenness of the change observed in a palaeontological break is unreal. We can never hope to know in the fossil state all the forms of life that have existed. Many of them were either not preserved or their remains were denuded away with the strata in which they were contained. Although many gaps in the rock-record in one area are supplied by fossiliferous deposits elsewhere, there must be many forms of life of which no trace was left at all.

The imperfection of the geological record is a fact of which the true value will probably never be estimated. But even after making the most liberal allowance for it the suspicion remains that it cannot account for everything. Even if we

examine the known fossil record as a whole we find serious gaps in the evolutionary sequence which defy explanation, for they occur even where the strata lie in a conformable series. On a small scale these gaps are familiar to the palaeontologist because on them depends the zonal classification of rock systems. But sometimes we find even big changes in the fossil contents of an apparently conformable series. In the Narrabeen stage of the Hawkesbury series in New South Wales the lower part contains a typical *Glossopteris* flora while only a few feet higher up, apparently without any serious break in the sedimentary sequence, there occurs a flora with *Thinnfeldia (Dicroidium)* and other forms, showing hardly any resemblance with the earlier flora. Even if a few plants occur in common between the two floras the general facies of the flora has completely altered.

Now, it is easy enough to imagine the extermination of a group, or even the greater part of a flora, as the result of a climatic revolution or through the introduction of new biotic factors. But what is difficult to picture is the sudden creation, apparently without intermediate forms, of a new group of plants or a new flora. It is with these sudden appearances that I shall mainly concern myself today.

Speaking of the great palaeontological break between the Palaeozoic and Mesozoic eras Professor Seward made the following remarkable observation about fifteen years ago.[1] He said

> "The threads of life seem to have almost snapped, and one wonders whence came the new arrivals which, to our restricted vision, appear as aliens rather than the direct descendants of Palaeozoic types ...... We may be led astray by a too rigid faith in the doctrine of continuity."

And again, referring to the periodic upheavals of the earth's crust and the birth of mountain ranges, he added

> "revolutions in the inorganic world ...... had their counterpart in the living world. Some chains of life were destroyed; a few persisted in an attenuated form, still producing an occasional new link, while from time to time fresh chains were forged."

Professor Seward was so impressed by the evident discontinuity between the life-lines of the Palaeozoic and those of the Mesozoic that he suggested that some of these fresh chains might even be without connection with those along which life had evolved in an earlier age.

Coming from a confirmed evolutionist, brought up in the old Darwinian school, and with an unrivalled experience of the botanical record of the rocks, these remarks could not fail to create something of a sensation. But there can be no

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[1] Seward (1924), p. xc; see also Seward (1922).

doubt that this picture of apparently unconnected chains of evolution, both in the organic and in the inorganic world, is strictly true to the observed facts of geology. In the absence of a satisfactory explanation a tentative hypothesis, however speculative, is better than a blank confession of ignorance, or a disheartening appeal to the imperfection of the geological record. And in this sense Professor Seward's idea of *actual* disjunctions in Plant Life through the Ages was a definite step forward.

But nevertheless, to most modern biologists any hypothesis of the origin of entirely new and unconnected lines of evolution must seem bold. And I confess that to me the sudden emergence of the *Glossopteris* flora from the Gondwana Ice Age remains as much of a mystery as my first experience of a Jack-in-the-box!

Among others who have discussed this question are the great French palaeobotanists Grand'Eury and Zeiller, Dr. Guppy, the late Dr. D. H. Scott and Prof. Paul Bertrand.

The Idea of Mutation applied to Fossil Forms: A French Theory of Metamorphosis

Grand'Eury, with his long experience as a field geologist in the Coal Measures of France, tried to apply De Vries's idea of mutation to the succession of species in the strata. He was impressed by the sudden way in which one species of a genus gave place, in a succeeding bed, to another resembling it but yet quite distinct, and without any evidence of intermediate forms.[1] This he observed not in isolated species, but in groups of them. Thus the species *Pecopteris dentata* Br., *P. arborescens* Br., and *Sphenophyllum filiculme* Lesq. were succeeded respectively by *Pecopteris Biotii* Br., *P. Schlotheimii* Goepp. and *Sphenophyllum oblongifolium* Ger. Similarly *Odontopteris Reichiana* Gut. he regarded as ancestral to *O. minor* Br. Such instances are, in fact, common enough, both in the plant and in the animal kingdoms: they supply the very basis for the zonal subdivisions of a rock-system.

One may, of course, say that these breaks are only apparent, not real. Dr. Scott did suggest that "the succession of species in a continuous series of beds does not necessarily represent the course of evolution. What we actually find may rather be the result of migration, and the origin of the new species may have taken place elsewhere."[2] And yet, with all the intensive work that has now gone on for decades, the missing links still elude us. Did they ever exist at all ?, we ask. Grand'Eury, following De Vries, answers No. So all our search was for nothing. For aught he can say, there might have been *a metamorphosis of one species into another*, brought about through an internal directive force like that in the life of a frog or of an insect.

1 Grand'Eury (1906) p. 25.
2 Scott (1924), p. 220.

So much for Grand'Eury's theory of the transformation of species in geological time: essentially, as we have seen, a De Vriesian idea. But these transformations would hardly make a revolution in a flora unless the change overtook the majority of species at the same time. Zeiller[1] took the idea a step further and suggested that mutations may have occurred not only in species but even in groups of higher rank, entire families arising at a bound from others pre-existing. Evidently he also thought that too much had been made of the imperfection of the record.

It would seem that certain facts of palaeobotany do lend some support to Zeiller's idea. Let us consider the geological history of two ancient families of ferns, the Zygopterideae and the Osmundaceae. Most botanists agree that there is a phylogenetic relation between them. If we compare the extreme members of these two groups we can find hardly anything in common between them. And yet there is a genus like *Grammatopteris* which links them so closely together that it is difficult to decide whether it is a member of the one family or the other.[2] The zygopterids, after making a number of vain efforts at survival, witnessed in the bizarre forms of their leaf traces, became extinct in the Permian and at the same time, as though from their ashes, arose the Osmundaceae, which survive to this day. The flowering plants seem to arise suddenly in the Lower Cretaceous, but just about this time a vast group, the Bennettitales, had become extinct, which for many years have been regarded among the nearest known relatives of the primitive angiosperms.

An idea somewhat similar to that of Zeiller was suggested in 1919 by Dr. H. B. Guppy.[3] According to him the evolution of flowering plants took place in two successive stages. In the first stage the great families of angiosperms were created. "It was an age of mutations, free and unchecked, and an age of uniformity of conditions." The second stage marked an era of differentiation in response to climatic and other changes. This is the era of the modern angiosperms, which may be said to have begun with the Cretaceous period. Although Dr. Guppy confines his remarks to the history of the angiosperms, it may be assumed that he would agree to apply the same general theory to other groups. Dr. Scott has shown, however, that the theory cannot stand a close analysis. For one thing, we know nothing of the time or the manner in which the first angiosperm families arose. Secondly, there is no evidence that conditions were uniform during the era of creation of the angiosperms, because this must have coincided with the era of differentiation of earlier groups such as the cycads, conifers and ferns which according to Dr. Guppy's hypothesis must have demanded varied conditions of climate.

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[1] Zeiller (1907).

[2] Sahni (1932); Corsin (1937).

[3] Guppy (1919).

Another ingenious theory we owe to the distinguished French palaeobotanist Professor Paul Bertrand. He explains in quite an original way the sudden appearance of the different groups of vascular plants in the geological scale. Like other modern biologists he has grown sceptic about the genealogical trees that were once so much in vogue. Many of us now agree that most of the great groups of the plant kingdom probably originated much further back than we were accustomed to believe. But Professor Bertrand takes the idea to the extreme point. According to him not only did all the great phyla of vascular plants arise quite independently of each other[1] but they originated simultaneously and as far back as the Archaean period. The fact that in the geological record the different groups come into evidence at different periods, often suddenly and without any precursors, he explains by reference to the well-known antithetic theory of the alternation of generations. The origin of the sporophyte from the gametophyte he regards as a sort of *metamorphosis* comparable with that seen among the insects and the amphibia. Professor Bertrand writes: "The gametophyte or prothallus is in fact a *larval stage* which may persist as such through millions of years till conditions favourable for a completion of the metamorphosis are realised."[2]

These prothallia or larval stages of plants are of various kinds. They are familiar to us in the Hepaticae, the Lycopodiales, the Psilotales and other groups. Often they are capable of perennating from year to year, and even of propagating themselves by buds and bulbils without the help of the sex organs.

Under certain conditions the dormant sex function becomes active and an embryo or sporophyte is formed as a sort of intercalation in the life-cycle. Like the prothallia, these sporophytes are subject to variation and differentiation in response to varied conditions of life, with the result that they evolve into so many species of vascular plants which we can now group into genera, families and orders.

If the course of events has been as here visualised, it becomes easy to understand Professor Bertrand when he says that we shall never find any Angiosperms as such in the pre-Cretaceous rocks, for the simple reason that these plants were then still in their prothallial or larval condition. With the dawn of the Cretaceous period the long-expected metamorphosis came and we see the angiosperms suddenly appearing in the form in which we know them today.

You will agree that Professor Bertrand's hypothesis is nothing if it is not ingenious. Its chief merit is that it appears to solve one of the greatest puzzles of palaeontology without an appeal to the imperfection of the geological record. One feels tempted to follow it up in all its implications, particularly in connection with the theory of recapitulation, but this will lead us rather into a side track.

[1] Bertrand et Corsin (1936), p. 465.

[2] Bertrand (1937), p. 1253.

These courageous attempts to explain the transformations in the organic world at least indicate that we have advanced well beyond the Darwinian era. We no longer seek to explain everything by pleading the imperfection of the geological record.

Bertrand's bold hypothesis cannot be proved, but there seems nothing inherently opposed to the idea. We all know the classical example of that Mexican newt, the axolotl, which, for all we can say, reached its full development for the first time when it metamorphosed in captivity in the Jardin des Plantes at Paris. In the plant world too we know instances of species permanently arrested in the embryonic or seedling stage.

Thus, to all appearance *Welwitschia* is an "adult seedling." The vegetative organs are arrested at the seedling stage, the reproductive organs are mature. As suggested several years ago,[1] it would be an experiment worth performing to try and cultivate this plant in an environment where it could develop its vegetative organs also into the adult stage. The peculiar cytological behaviour of the gametophytes may be in some way connected with the hard life the plant has to lead. The restricted distribution of this aberrant monotypic genus on the edge of the S. W. African desert suggests that it is a species fallen on evil days, fighting against the forces of extinction by husbanding its vegetative resources for the more urgent demand of reproduction, like the precociously mature children in a starved population. The case seems parallel to that of the ephemeral flora of high altitudes and high latitudes where the season is too short to allow of a full vegetative development before flowering sets in and the seed must be formed against the approaching frost. I am reminded of a yellow carpet of flowering seedlings of a composite which I saw during a trek in Ladakh in the summer of 1920. They were eking out a precarious existence under the shelter of overhanging rocks at a height of 15,000 ft. above sea level on the Rupshu plain.

The case of *Phylloglossum* is known to all students of botany. It affords another instance of arrested development, the spore-producing stage supervening soon after the embryo is able to support itself. Perhaps one day we shall have experimental vindication of Treub's theory of the protocorm. For it is by no means inconceivable that in these days of hormones the protocorm of *Phylloglossum* may be induced (like the axolotl) to mature into a fully developed *Lycopodium*-like vegetative body before it begins to produce sporangia.

From the work of Gudernatsch[2] we know that tadpoles fed upon thyroid extract metamorphose prematurely into pigmy frogs, while the same larvae, if given thymus extract, grow into giant tadpoles and postpone their metamorphosis. It is possible that Klebs's classical experiments on the artificial control of thallophytic life-histories will be extended to the lycopods and even to higher plants.

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1 Sahni (1925), p. 213, footnote.

2 Gudernatsch (1912), p. 323.

I may seem rather to have digressed from the main track of my theme, but what I have attempted to bring to the fore is the great importance of the environment not only in the life-history of the individual but also in phylogeny.

Genetic Consequences of the Impact of Environment

But perhaps the most significant advance in this connection has been recorded within the last two decades in the field of cytogenetics.[1] From palaeontology to cytology seems such a far cry that very few students of fossils have yet concerned themselves about these recent developments.

Speaking for myself, I confess that until a few months ago I had no idea of the bearing of these results upon our present problem. In an address recently delivered in Calcutta I was speculating on the sudden appearance, over a vast southern continent, of the *Glossopteris* flora immediately after the Gondwana glaciation. There can be little doubt that this flora was at least largely an indigenous product; it must have been evolved in Gondwana Land itself, from the hardier elements of the pre-glacial flora that survived the Ice Age, sheltered in ravines, on nunataks and in other local asylums. As the ice gradually melted away these few survivors must have found the conditions almost ideal for rapid multiplication, evolution and dispersal. And I tentatively suggested that "It would almost seem that exposure to the rigours of the climate had quickened the pace of evolution, as if by inducing saltations on a large scale: a sort of natural vernalisation, affecting not only the individual life-cycle, but the rate of evolution of species, possibly through aberrations in the nuclear cycle."[2]

In vernalisation a temporary chilling of the early stages of germination quickens the rate of development. The life-history of the individual is telescoped into a shorter span of time. I am not aware that anyone has studied the cytology of vernalised plants. It would be interesting to know whether this telescoping effect is the outward manifestation of a detectable chromosomal change. Other things being equal, even this kind of an acceleration would hasten the rate of evolution of species by producing a larger number of generations in a given period of time. But I meant to carry the analogy much further by suggesting that *as a direct result of the glacial conditions there might have been produced chromosomal aberrations and gene mutations leading to far-reaching genetic consequences.* At the time these ideas occurred to me I had no conception of the remarkable results already achieved in recent years by a number of workers in cytogenetics—results based not only upon observation but upon experiment under controlled

[1] See the works by Dobzhansky, Sax, Timoféeff-Ressovsky and "Current Science," Special number on Genetics (1938).

[2] Sahni (1938), p. 13.

conditions. The fact is that a large number of chromosome mutations have been produced artificially in a surprisingly wide range of plants.

Although this recent work is almost entirely the growth of the last two decades —indeed most of it is the product of only the past ten or twelve years—the literature is already too vast to be considered here in detail. Nor can I claim to be able to review it critically, though it is only fair to add that the importance of these results in the origin of new species and genera has been questioned, notably by Heribert Nilsson.

A brief statement of the recorded facts must suffice. Among the many agents that are now known to cause these aberrations are various chemicals, such as chloral hydrate and colchicine, narcotics and infections of various kinds such as may be due to fungal or insect attacks, short-wave radiations such as X-rays and ultraviolet rays, centrifuging, grafting, hybridisation and, what is of special interest from our immediate point of view, extremes of temperature, both high and low.

Confining our attention to the temperature effects alone, we are introduced to an impressive series of works by a number of authors whose ranks are steadily growing. I can only name a few of them: Avery, Belling, Bergner, Blakeslee, Borgenstam, Chizaki, De Mol, Dorsey, East, Elmanov, Farnham, Fernandes, Hagerup, Hollingshead, Koshuchow, Kostoff, Lundegardh, Matsuda, Michaelis, Müntzing, Navashin, Peto, Radjably, Randolph, Rybin, Sakamura, Sax, Schloesser, Shimotomai, Takagi, Ternovsky and Tischler.

The range of genera on which these observations and experiments have been made includes, among many others, *Capsicum, Crepis, Cucumis, Datura, Epilobium, Hordeum, Nicotiana, Oenothera, Petunia, Pisum, Secale, Syringa* and *Zea*.

The cytological aberrations observed or induced affect both the vegetative and reproductive cells, and include, besides other irregularities, haploidy as well as various grades of polyploidy. In the roots of a plant the mitosis may be disorganised and a doubling of chromosomes may result (Lundegardh). In *Datura* non-reduction in triploid and diploid forms may be greatly increased by temporary chilling (Belling and Blakeslee). In *Syringa* hyperchromosome gametes were produced as a result of low temperatures during the division of the pollen mother cells (Borgenstam). In *Nicotiana tabacum*, at a temperature of $-0{\cdot}5^\circ$C, a doubling of the chromosomes was observed in 20—25% of the pollen mother cells (Elmanov). By treating plants of winter rape to low temperatures during meiosis 8—13% of tetraploid plants were obtained (Schlösser). Heteroploid plants were produced in *Epilobium* and *Oenothera* by subjecting the plants to a sudden reduction of temperature during the period of flowering (Michaelis). Irregularities leading to the formation of dwarf as well as giant pollen grains were observed as a result of temperature effects during the division of the pollen mother cells (Shimotomai, Matsuda). In *Capsicum* Kostoff induced irregularities in the meiosis, resulting in polyploid gametes, by treating plants with

alternating heat and cold. The case of rye is unique. The normal chromosome number is 14 (n=7), but we now know a haploid produced by cold treatment, a tetraploid obtained by heat treatment and a triploid formed by the twin seedling method (Müntzing). Other irregularities under the effect of high temperatures are reported by De Mol, Chizaki, Randolph, Sakamura and others.

Among the most significant observations in nature are those recorded by Hagerup, Müntzing, Navashin and Tischler. An adequate idea of these remarkable works can only be gained by a reference to the original sources. But I shall attempt briefly to review these results as they strike a palaeobotanist enquiring into the plant revolutions of the geologicalp ast.

Hagerup's interest in this field led him to study cytologically the floras of extreme climates, for example, those of Greenland, Iceland and the Faroe Islands on the one side and, on the other, the flora of the hot and arid African Sahara near Timbuctoo: regions where the struggle for existence is keenest and "natural selection" of the hardiest forms takes place. *Empetrum hermaphroditum*, a new tetraploid bisexual species described by him in 1927, is a genetically constant type, presumably derived from the unisexual diploid form *E. nigrum*. It lives in higher latitudes than its diploid progenitor, as if tetraploidy had given it greater hardiness and vitality. In the genus *Bicornes*, which has a graded series of species (n=6), ×2, ×3, etc. up to ×8, Hagerup finds that it is always the highest polyploids of the series that grow furthest north. In the Sahara, too, he found that the polyploids differed from the diploids morphologically, ecologically, geographically and genetically. They were usually the largest individuals ("gigas" forms) and were more hardy against the heat and drought. Of three species of *Eragrostis* at Timbuctoo *E. cambessediana*, with n=10, is an annual which dies down in the hot weather; *E. albida*, with n=20, lives in drier situations on the dunes and is a perennial; the hardiest form is the giant *E. pallescens* (n=40).

Hagerup's observations on polyploid ecotypes in *Vaccinium* are equally interesting. *V. uliginosum* forma *microphylla* (n=12) is a dwarf diploid with a circumpolar distribution, while the tetraploid form *genuina* (n=24) extends far and wide into Central Asia, Japan and N. America. Thus it is not always the form with the greatest number of chromosomes that is the hardiest. In *Orchis* Hagerup finds that "the tetraploid individuals have by far the greatest ecological and geographical range," extending furthest north in the Faroe Islands and N. Iceland. They also have a later and longer flowering period than the diploid forms.

Among the few records from this country relating to this question is Bhaduri's (1933) statement that the common weed *Solanum nigrum* is represented in India by diploid, tetraploid and hexaploid races. Since in Europe and North America only hexaploids have been found, a southern origin for the species seems suggested. It would be interesting to know whether the diploid,

tetraploid and hexaploid forms show a progressive geographical range even within India.

Müntzing (1936) has given an admirable analytical summary of the literature on polyploidy. While some authors, like F. von Wettstein, are sceptic about the significance of polyploidy in the origin of new species, Müntzing belongs to the larger group of geneticists, including Hagerup, Tischler, Blakeslee, Avery, Jörgensen, Darlington, Babcock, Sax, Fernandes, Lilienfeld and others, who attach fundamental evolutionary importance to it.

Müntzing (1930) for the first time succeeded in "creating" a synthetic species *Galeopsis Tetrahit* (n=16) by crossing *G. pubescens* (n=8) with *G. speciosa* (n=8); similarly Heribert Nilsson (1931) combined *Salix viminalis* (n=19) and *S. caprea* (n=19) into *S. cinerea* (n=38). Both the synthetic forms were already known to occur in nature, and presumably arose by hybridisation. These facts are a striking vindication of Winge's theory of the origin of polyploids and of Lotsy's (1925) idea of the origin of new species by hybridisation. More recently (1935) the Japanese botanist U obtained *Brassica napus* (n=19) from *B. campestris* (n=10) and *B. oleracea* (n=9).

This brings us to the fascinating subject of intraspecific chromosome races, of which Müntzing has made a comprehensive study. The great majority of these are intraspecific polyploids, but sometimes it is difficult to decide whether we are not dealing with two or more closely related but distinct species. Comparing the morphological characters of such polyploid races with those of experimental polyploids the conclusion is that an increase in the number of chromosomes very often goes hand in hand with a general quantitative increase in the body of the individual, expressed in the term gigantism. Thus, compared with the diploid the tetraploid may be more robust, have a thicker and taller stem, larger leaves, larger flowers and larger seeds and pollen grains,[1] even a larger cell size. But "there is an optimum for chromosome increase beyond which the individuals become less vigorous if they are viable at all."

Similarly, chromosome increase is frequently expressed in a change in ecological behaviour and geographical distribution. We have seen that polyploids, being on the average more hardy, often have a more northern and alpine distribution; or they may be better able to withstand extremes of heat and drought. It would almost seem as if any adverse conditions of climate may bestow hardiness upon a species.

Again, through a chromosome increase a race of annuals may become a race of perennials,[2] and Müntzing (1936) actually finds that within a given genus the

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1 Müntzing (1936 *a*).

2 It may be useful to compare the chromosome numbers of the trees, shrubs and herbs in the families of angiosperms. This may give a clue as to whether the tree habit is primitive, or derived from the herb and shrub habit through a chromosome increase.

perennial species on the whole have higher chromosome numbers than the annuals. Fagerlind is even reported to have found that the summer form of one and the same species (e.g., *Galium palustre*) may be a diploid while its autumn form is octoploid.

These facts have an obvious importance in the invasion of new areas by hyperchromosome forms, which then are able to hybridise with forms previously inaccessible to them. Similar ideas have been expressed by Navashin, whose work on chromosome races in the genus *Crepis* is well known.[1]

Professor Tischler of Kiel has made statistical studies on chromosome numbers in relation to climate, ecology, geographical distribution and taxonomy, considering for the first time (1935) the flora of a province as a whole.[2]

After a cytological analysis of the flora of the Halligen,[3] a group of small islands in the North Sea liable to frequent flooding by sea water, Tischler finds that, among the weeds introduced by man, those that have become permanently settled to these difficult conditions are 100% polyploids while others, which are occasional visitors not yet completely acclimatised, have only 30% polyploids. The indigenous flora has 50%, that is, about the same percentage as Schleswig-Holstein, the northernmost province of Germany. In Schleswig-Holstein, we know the chromosome numbers of as many as 73% of the species, and of these, according to Tischler, about half are polyploids. About the same percentage of polyploids occurs in East Prussia. Iceland, so far as available records show, has 55% while Sicily has only 30% polyploids. From such comparative data on the chromosome numbers of northern and southern floras in Europe, Tischler draws a conclusion of special interest in our present enquiry. He writes[4] "It seems reasonable to conclude that the influence of the glacial periods [of the Pleistocene age] has enhanced the number of polyploids and decreased that of diploids, for the latter could not survive in the competition."

The great frequency of polyploids among angiosperms (it has been conjectured that about half the angiosperms are polyploids) and the existence of so many series of chromosome multiples, indicate that polyploidy plays an important part in the origin of new species. As Fernandes (1931) says, it is reasonable to agree that it may have influence on the evolution of genera.

Enough has been said to show how intimately this recent work has brought our problems of cytology into relation with the problems of plant-geography, adaptation and evolution. One might well ask, if only Darwin and Wallace had had an

[1] Navashin (1925); (1929).

[2] Tischler (1935).

[3] Tischler (1937); (1937 *a*)

[4] Tischler (1937 *a*), p. 166.

kling of these remarkable results in their day, what use would they not have made f them in the theoretical structure of their great work ?

But what of that problem of *revolutions* in the plant world, which is here our main concern? That question still defies solution, but after what we know of the direct effect of climatic factors on the genetic constitution of plants is it unreasonable to relate at least some of the great transformations in the plant kingdom with climatic revolutions in geological time? Cannot the Gondwana glaciation, for example, have been directly responsible for initiating changes which resulted in the rapid evolution of a flora that was essentially new? For, if it has been possible for us to produce such startling results as those briefly described above within the brief space of two or three decades, is it impossible that climatic oscillations on that vast continent, acting on a flora through thousands of years, may in the course of generations have induced changes of a revolutionary nature ?

It must be confessed that even if the hypothesis here suggested is correct we shall still have to assume that many intermediate types must have perished without leaving a trace, or that their remains should be looked for in the very earliest plant-bearing Gondwanas, *even in the glacial beds themselves*. This will show at once how important it is to investigate these earliest of the Gondwana floras. For at present the differences between the pre-glacial and post-glacial floras are too large, both in the degree of the change and in the number of forms affected : in none of our experimental mutations have we yet been able to produce changes of such magnitude.

Thus the main problem of organic revolutions stands where it was, but the broad fact remains that some of the periods of the most active creation of new forms of life have coincided with the physical revolutions of the geological past.

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